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DISCOVERY

A MONTHLY POPULAR JOURNAL OF KNOWLEDGE

EDITED BY A. S. RUSSELL, M.C., D.Sc.

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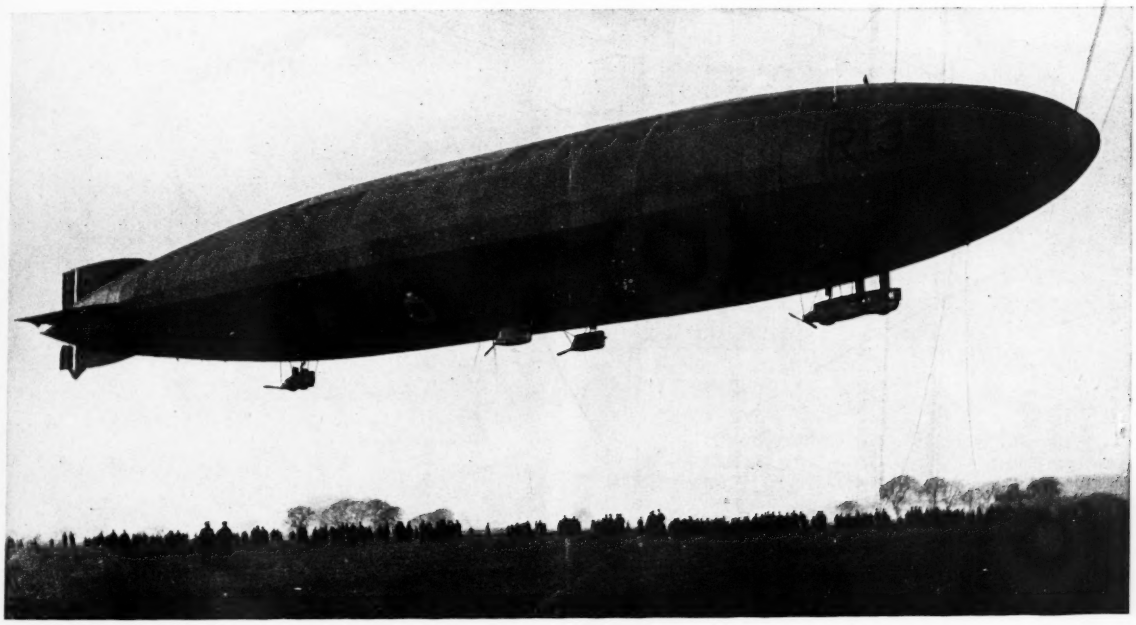

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JOHN MURRAY, 50A ALBEMARLE STREET, LONDON, W.1.

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Editorial Notes

THE possibilities of a trans-Pacific flight has been discussed by two writers in a recent number of the periodical *Aviation*. A look at the map will show how much longer a flight from, say, California to Japan is than one from Canada to England. There are several likely routes that might be tried in attempting to make such a flight. There is, of course, direct flight from America to Asia over about 4,500 miles of sea. A halt might be made, however, at a suitable intermediate spot such as Honolulu in the Sandwich Islands. In this case the direct water-stretches would be replaced by two of about 2,100 and 3,400 miles. A third possible route would be to fly round the American and Asiatic coasts, the only stretch of sea to be flown over then being the short distance across Bering Strait. This would involve a flight over a distance from 6,000 to 8,000 miles, depending upon where the flight commenced and terminated.

* * * * *

At the present time the record flight of a lighter-than-air machine is that of a Zeppelin during the war which flew 4,000 miles in 100 hours, and of a heavier-than-air machine that of the Vickers-Vimy which crossed from Newfoundland to Ireland, a distance of about 1,900 miles. Considering both radius of action and reliability, the authors consider that the rigid airship stands first, the non-rigid second, and the sea-plane third. They have worked out five principal routes after considering the lengths of the stages of the flight, meteorological conditions, and facilities for landing, repair, and re-fuelling. Each route possesses certain advantages as regards the type of machine in which the flight is proposed. The conclusion of the matter is that a rigid airship should be able to do the flight to-day without a stop; a heavier-than-air machine, however, could do it also, but only by stopping for re-fuelling.

* * * * *

It is now well known that Colorado is the chief place on the earth's surface at which radium may be found. The other and better-known sources, namely, the mines of Bohemia, Saxony, and Cornwall, contain small quantities of ore compared with the amount found near Denver. The ore there is called carnotite, and has been mined for many years for the substance vanadium (a constituent of certain steels) which it also contains. The size of the deposits varies from a few pounds to many tons, and altogether in the area explored there is estimated to be about 100,000 tons of ore. The quantity of radium in this mass may be calculated from the percentage of uranium (about 1·5 per cent.) which it contains. It is about 15 ounces avoirdupois, or 425 grams. This may not seem a great amount, but it is about 425 times more than most research-workers have ever seen or handled. Radium is one of the few things which has not advanced very much in price since 1914, but its advance in the twelve years before the war was so great that it may have felt it had already done quite enough in that particular way. In 1902 the price was 5*s.* a milligram—i.e. £250 per gram—next year it was £300 per gram, and in 1904 £1,000. The present price is about £25,000. In spite of this the demand for it is steadily increasing. It is to this American source of supply that research-workers, hospitals, and all who need radium must turn for the material itself; it is

harder, however, to indicate the source they should seek to obtain the money to pay for it.

American chemists have succeeded in preparing leather from the inner membranes and the outer skins of sharks. As the yearly catch of these fish may be as high as ten thousand, an industry of some importance has been started. It seems that the tanning of the shark-skins was a great difficulty, as this could not be accomplished by the processes usually employed. Some ingenious chemist found out, however, that the outer skin could be separated into two layers. The inner one was a leather of good quality, and the outer, which was very hard, tough, and waterproof, was found suitable for soleing boots and shoes. The lining of the shark's inside is found suitable for gloves and fancy goods. Altogether, then, the shark has been found distinctly useful in America.

* * * * *

From Canada there comes a book in which the question, Has the North Pole been discovered? is discussed. The less sophisticated of us in this country believe that Commander Peary got to the Pole and that Captain Cook did not. The author, Mr. T. F. Hall, formerly a captain in the American Merchant Service and past member of the Nebraska legislature, has been investigating this point and has begun to wonder. Indeed, he comes to the view that there is no conclusive evidence that either Peary or Cook reached the Pole. He began his investigations with full faith in Peary, but evidently he has not continued till this faith has been fully restored to him. He thinks that Peary's different accounts of the journey are inconsistent, and are contradicted on essential points by those of the negro who was his companion; that the speeds claimed by Peary in his last journeys are impossible; that some of the photographs, from the very look of them, could not have been taken at the latitudes claimed for them, and so on. It is a pity that this book did not appear in Peary's lifetime. A gramophonic record of Peary's remarks on reading a review of it by Captain Cook (were he alive too) would have been highly interesting and no doubt instructive. This "doubting Thomas" attitude is typical of to-day, when the maximum intellectual satisfaction seems to be attained by many only when they have perfectly negative opinions on every subject of discussion except eating, drinking, and the weather. The question, however, may be safely left to American geographers.

* * * * *

An important oil-well has recently been located in the North-West Territory of Canada. Optimists think it may develop into the largest oilfield in the Empire —perhaps even in the world. The site was chosen in 1914 by a party of English geologists on behalf of a Canadian syndicate, but the war, difficulties of transportation, and other causes have delayed matters. The well is situated on the banks of the Mackenzie River within a few miles of the Arctic circle. It is about 1,000 miles N.N.W. from Edmonton, the capital of Alberta, and no less than 1,300 miles' journey by water beyond the northern limit of the railroads. The actual drilling did not commence till the spring of this year. At a depth of 800 feet in the first test well a large quantity of high-grade oil was struck, and it is expected that the well will produce several thousands of barrels of oil per day.

The long distance from civilisation, the severity of the climate, and other causes are holding up the work during the winter, but in next spring great hopes are centred on what a geologist who has been out there describes as "the biggest oilfield in the world."

* * * * *

The question of the age at which rubber trees are likely to become exhausted is one that is raised from time to time; it has so far not been satisfactorily answered. The Rubber Growers' Association recently received a communication from a company showing that its agents in the Federated Malay States had reported that a large number of estates were obtaining a reduced crop from old rubber trees, and inquiring whether any statistics were available on the subject. Assuming that yields fell off at a certain age, the company was anxious to know at what age this took place, and the extent of the failure to yield. It is admitted that there do not appear to be any statistics bearing on the question.

* * * * *

A number of members of the committee who have had the matter under investigation have been unable to collect any evidence to show that there is a falling off in yields owing to the increasing age of the trees. The decreased yields are in a large measure, in the past, due to such causes as over-tapping and to insufficient time being allowed for bark renewal. They consider that better conservation of bark and lighter tapping, coupled with cultivation of the soil and the careful nursing of the trees, will prove beneficial. Provided trees have not been affected with disease, they should regain their former latex-yielding qualities. There is every reason to believe that the yield increases with the advancing age of the tree.

* * * * *

The subject is one which is of the first importance to the industry. There certainly exist several of the trees planted in the Botanical Gardens at Ceylon, which are forty-four years of age and are still yielding rubber freely; but these are not grown under

estate conditions. Statistics of yields from old rubber would be an immense advantage. Generally speaking, however, it may be stated that the oldest planted trees, if they have been properly treated, show little sign of any failure, but continue yielding latex.

* * * * *

An American magazine has recently published a note on dry-rot which may be new to many readers. The term is loosely applied to any kind of decay in wood, for wood which is kept sufficiently wet cannot decay. In the more limited sense, however, the term applies only to the work of a certain house fungus, *Merulius lachrymans*, which is frequently found growing in wood without any apparent supply of moisture. It cannot infect thoroughly dry wood, however, but, if it obtains sufficient moisture to germinate, it can make its way a very long distance into dry timber because it draws the water necessary for existence from the supply through a conduit system of slender, minutely-porous strands. Wood in the advanced stage of dry-rot is shrunken, yellow, or brown in colour, and filled with radial and longitudinal shrinkage cracks roughly forming cubes. Not only furniture but also logs in storage may become infected. Hard woods are more commonly immune than soft.

* * * * *

English books seem very scarce at various places on the Continent. A correspondent writing from Louvain says, "I have been to-day to the library here to see what books there are on the electrical theory of matter, and I was astonished to find there was none. Surely it is unfortunate that in all the books which England has collected and sent over here there should be none whatever representing English scientific thought and achievement. Thomson, Rutherford, Soddy, Ramsay, and Kelvin ought surely to be represented." We agree. A letter recently appeared in *Nature* on the same topic from a correspondent in Eastern Galicia. The writer declared that in the libraries of Warsaw, Lwów, and Krakow the English books could be counted on the fingers of the hands, and English periodicals simply were not there at all. It is well to know that the Anglo-American University Library of Central Europe is engaging itself in supplying this unfortunate deficiency. A little goes a very long way when periodicals and books are sent from this country to the stricken cities of the Continent.

* * * * *

I have received from Messrs. Bowes & Bowes, of Cambridge, a little book called *The Post-Prandial Proceedings of the Cavendish Society*. This book is a collection of topical verse on modern physics and other matters written by members of the Physics Research Society of the Cavendish Laboratory. It has been privately printed for sixteen years, but this, the fifth edition, is now published in the ordinary way for the first time. It will interest all those who are, or have been, connected either directly or in spirit with the splendid work on modern physical problems which has been one of the glories of Cambridge since the days of Clerk Maxwell.

* * * * *

Clerk Maxwell, who was quite a genuine poet in his day, wrote the first poem in the book, but undoubtedly the verses of A. A. R. read with the best swing. A part of one of his efforts may be quoted. Instead of saying in cold and technical prose that an α-ray is a material particle shot out by certain radio-active bodies at a speed of about one-twentieth of that of light, and carrying an electric charge of two, the poet says:

Air: "A Jovial Monk"

"An alpha ray was I, contented with my lot;
From Radium C
I was set free,
And outwards I was shot.
My speed I quickly reckoned,
As I flew off through space,
Ten thousand miles per second
Is not a trifling pace!
For an alpha ray
Goes a good long way
In a short time t,
As you easily see;
Though I don't know why
My speed's so high
Or why I bear a charge $2e$."

Two further verses describe subsequent episodes in the short but exciting life of the α-ray. As is well known, an α-ray when it has slowed down behaves like an atom of helium; it is also well known that several workers in radio-activity have had the uncommonly happy experience of winning the Nobel Prize (about £8,000), but that is prose; here are the facts in verse, the α-ray is still speaking:

"But now I'm settled down, and move about
quite slow;
For I, alas,
Am helium gas
Since I got that dreadful blow.
But though I'm feeling sickly,
Still no one now denies,
That I ran that race so quickly,
I've won a Nobel Prize.
For an alpha ray
Is a thing to pay,
And a Nobel Prize
One cannot despise,
And Rutherford
Has greatly scored,
As all the world now recognise."

Living Backwards

By J. S. Huxley, M.A.

Fellow of New College, Oxford

ONE of the great scientists of last century declared that Science was organised common sense. In a way it is; but in another way, how emphatically it is not! Perhaps we might say that it is a continual upsetting of the judgments and most firmly-held doctrines of common sense by an extension of common sense's own methods.

The motion of the earth round the sun, the mutability of species, the possibility of interchanging all the different forms of energy, the production of water by burning hydrogen in oxygen—how unlikely are all these facts, how much opposed to the common-sense ideas of common-sense people, but how undeniably true!

Common sense is content to generalise broadly and vaguely from just so much experience as necessity thrusts under its nose; science is for ever searching for more experience, which it may compare with what it already possesses. In its method of dealing with facts, science is but organised common sense; but in its method of collecting facts, it is common sense no longer. Common sense is content with every-day; but science is organised curiosity.

This part-antithesis between science and common sense is to-day being once more exemplified in relation to some of the most fundamental processes of life. To common sense it would seem obvious that development is a closed cycle, each stage leading forward in an inevitable series to the next. The fertilised germ becomes the embryo, the embryo becomes the young organism; youth leads to maturity, maturity to age, and age to death. That is the normal cycle in man and in the animals and plants with which common sense is familiar; it knows no facts that contradict the notion, and so the notion becomes a generalisation.

But science is not content with the familiar. An organism is an organism, whether it be a jelly-fish, a snail, or a dog; and all organisms are related. In some organisms the processes of development are not necessarily irreversible; and we are approaching the time when we shall be compelled to assert that these processes are fundamentally reversible, and that the irreversibility of our own life-history is only secondary.

Among marine animals there exists a curious group, the Tunicates, for long classified with the shell-fish until a study of their embryology revealed that they passed through a tadpole-like form, and that they were, in fact, poor relations of the Vertebrates, fixed by the head, having lost their eyes and ears, and feeding on microscopic particles brought in by a ciliary current. One of them, Clavellina by name, was found by Driesch to possess the extraordinary faculty of returning to a simpler condition. The adult animal, pellucid, revealing to the microscope every detail of its elaborate anatomy—gill-slits, food-groove, stomach and intestine, liver, heart, minute brain—can, when damaged or placed in unfavourable conditions, altogether change its aspect. Its inhalant and exhalant orifices close, it gradually becomes opaque as it shrinks, and its various organs grow simpler and simpler, the cells of which they are composed losing their characteristic form, and becoming all approximately cubical. Finally, in the course of a week or two, the creature has become nothing more than an opaque white ball, covered with a single layer of epithelium; the internal organs are reduced to a few closed vesicles, and the space between them and the skin is packed tight with the blood-corpuscles. If now replaced in pure sea-water, it will retrace its upward development and become a normal individual again, perfect, but smaller, since a certain amount of material has been used up in the metamorphoses. The animal has been experimentally made to repeat this reversal and subsequent blossoming-out three times; and if it could be supplied with enough food to bring it up to its original size (unfortunately it is difficult to feed in the laboratory), it could no doubt continue to do so indefinitely. Such a process, which we may style dedifferentiation followed by redifferentiation, is clear evidence of the possibility of reversing development.

A different type of reversal is seen in many common flat-worms and sea-anemones. The Planarian flat-worms are among the simplest forms of three-layered animals. None the less, they have a sufficiently complex organisation, with brain-ganglion and nerve-cords, prehensile proboscis, branched digestive and excretory systems, simple eyes, and very elaborate reproductive organs. The sea-anemones are, of course, highly organised polyps—two-layered creatures, with radial symmetry, a circle of tentacles and a central cavity divided up by a number of strengthening partitions.

If one of these animals is starved, it does not die after losing a quite small amount of weight, as does a man, but gets smaller and smaller, saving itself from death by feeding upon itself. Sea-anemones several inches long have been made to shrink until they were no longer visible to the naked eye.

It is, however, the flat-worms which have been most thoroughly investigated. Some years ago, it was pointed out that a flat-worm which has been much reduced in size by starvation comes to resemble similar-sized young individuals of the species in all

details of shape and proportion. Later, Professor Child, of Chicago, went further and showed that these reduced worms were young, not only in appearance, but in behaviour and physiological working too. They were, in fact, young in all essentials, and if food was given them, would once more grow up into normal adults. By means of alternately feeding and starving a single worm, Child was able to keep it within prescribed limits of size and of physiological age, while other individuals of the same brood had given rise to eighteen generations—a period which, translated into human terms, would take us back to Chaucer's time. The process could apparently have been indefinitely continued, but the Professor had sufficiently proved his point, and turned to other problems.

So the *Elixir Vitæ* has been found at last, and revealed in startling simplicity as enforced periodic starvation. Unfortunately, it is not a panacea, for it does not work with any organism higher in the scale than a flat-worm. . . . Ironical Fate !

There remains to be noticed another very curious form of reversal, which is interesting on account of the light it throws, in conjunction with the other processes we have been considering, on happenings in the history of the higher animals and of man himself.

Perophora is the name given to an Ascidian nearly related to Clavellina, but consisting of a series of very small green individuals, springing at more or less regular intervals from a creeping tube or stolon filled with blood, much after the fashion of strawberry plants along a runner. When this animal is placed in unfavourable conditions, it begins to shrink in exactly the same way as Clavellina, but instead of becoming a dense opaque ball, it grows smaller and smaller, and finally ceases to exist at all, having been completely resorbed into the stolon.

When this curious process is investigated, it is found that the various organs of the body become smaller, owing to their component cells successively leaving their places in the tissue and passing out as free units into the blood-stream. It is as if a house were to unbuild itself, the bricks flying out of their places in the walls, and the rooms gradually shrinking until nothing was left but a courtyard filled with loose brick-heaps.

Through all this elaborate unbuilding, the stolon remains perfectly normal, and may even grow. It would appear, therefore, that the individual proper is more easily affected by adverse conditions than is the stolon, and that this differential susceptibility, as we may call it, leads to the reversal of development in one part only of the whole organic system.

This is borne out by the fact that when the same system is kept in the best possible conditions, save for the fact that it is starved, it is the individual which absorbs and feeds on the stolon. In brief, in such a system, one part will be dominant ; and we can give dominance to one or to the other by varying the conditions.

Differential susceptibility is a universal phenomenon in biology ; for, in fact, what we imply by the term is simply that the parts of an organism are not all alike in their sensitiveness to external agencies.

When correlated with another fact in biology, however, it becomes of great significance. This other fact is the existence of what have been called axial gradients in the organisation of animals and plants, persisting often throughout life, but always existing during development.

By an axial gradient is meant a succession of parts from one end to the other of the main axis of a living organism, each part being successively a little less active in its metabolism, its general chemical reactions, than the one before. For instance, in a Planarian, or again in an embryo mammal, it would appear that the head is the most active region, the region where metabolism is at its quickest, and that as we proceed towards the tail, the rate of metabolism (using the word in its most general sense) becomes less and less. This conception again we owe to Professor Child. Into its details we cannot here enter ; it must suffice to look at some of its consequences.

Other things being equal, we would expect that a piece of machinery which is working quickly will be more damaged when an iron bar, say, is thrust into its midst than if it were working slowly. The analogy seems to hold for organisms. Poisons, whether narcotics, or those that stop oxidation, or acids, or mercury salts, when administered in such great dilution as not to kill but only to damage, act first and most strongly on the more active parts of the organism. Or if their strength is such as to kill after several hours only, the more active parts will die first, and death will creep down the axial gradient.

It follows that we should be able to find a dilution of poison which will affect the more active parts alone, and leave the less active parts to all intents and purposes undamaged.

This has been done. If, for instance, when a developing egg of a marine worm such as Chætopterus is placed in a very dilute potassium cyanide solution, the apical region of the larva, with its little sense-organ and tuft of cilia, is acted upon and fails to grow to the normal size. The hind-region of the body also, which is preparing for active growth into the trunk of the worm, and is found to start dying as quickly as the " head " region in dilute poisons, is reduced in the same way. The middle region of the body, however, is not affected ; and since there is a definite amount

of yolk in the egg, available for the embryo's first period of growth, it seizes upon what the head and tail regions have not been able to profit by, and becomes not merely relatively, but also absolutely bigger.

We thus see that a part possessing more active metabolism has in normal circumstances a first call upon the available food supply; it is also, however, more susceptible to harmful agencies, so that these, acting in certain intensities, upset the relative powers of the various parts to utilise food supply.

Normally, the proper balance of any organism is maintained by the interaction of its different parts, struggling for food, stimulating or depressing one another, embarking on overgrowth, or being reduced by resorption. Indeed, the organism in a quite real sense *is* the interaction of its parts, and in no sense merely their sum. The form, the rate of growth, the actions, the span of life itself—all are determined by the interaction of the parts of the incredibly complex self-regulating mechanism.

The rôle of the dominant region in this flying play of forces is of extraordinary importance. Again the Planarians will illustrate the principle for us. These flat-worms have a remarkable power of regeneration: the body may be chopped up into pieces, and each piece may reorganise itself into a new whole. Each piece may, but does not always do so: this depends on the age and condition of the original animal, and on the external environment. Now two things are noticeable. If regeneration is to occur, the first part to form will always be the head, the dominant region which in normal development also is first laid down; and secondly, the organs of the piece will only be reorganised if a head is formed. The most prominent of these in the central region of the body is the pharynx.

If an animal is cut in two behind the pharynx, the hinder half may form a head, or it may not. If it does, a pharynx will shortly afterwards appear in its proper relative position; if it does not, no pharynx will arise.

We may say that in animals capable of total regeneration, like Planarians, the tissues when cut will respond by forming a new dominant region; but when a dominant region has once been formed, they react by forming the various organs of the body in their due relation along the axial gradient. The working of the living substance of the species is thus altered under the influence of the controlling dominant region; but when this is removed, as by a cut, any region of it is capable of remodelling itself into a fresh dominant region.

This potential equivalence of all regions ceases to exist in higher forms, but none the less the dominant region exerts a profound control over the rest of the system. If, for instance, the limb of a young mammal such as a rabbit is exposed to X-rays of a certain intensity, it will develop into a small and stunted thing. But if the head be exposed to X-rays, not only will the head grow up stunted, but the whole of the rest of the body, though shielded from the effect of the X-rays, will be stunted too. The brain is the "dominant region" of the mammal, and general damage to it causes impairment of function in all the members.

Indeed, in the highest organisms, and more particularly in man, the whole creature may with propriety be thought of as consisting of two main parts—the conscious mind and the non-conscious nerve-centres in the brain on the one hand, and on the other the whole of the rest of the body, which is but the brain's servant and box of tools.

But even within the nervous system and within the mind, the parts are built up into a hierarchy of dominant and subordinate.

It was Hughlings Jackson who first gave this idea full weight, and in our own day Head especially has upheld and illuminated it.

The conscious centres of will and attention are dominant over unconscious centres in the brain, and these again over reflex centres in the spinal cord. Not only this, but education and mental and moral growth mean nothing else but a subordination of the will and the attention to a changing series of ideas, which rises (if the education is good, the mental development a true one) in a scale from the simple to the complex and general, from the instinctive to the reasoned, from the selfish to the altruistic. Each of these ideas represents a period of our life, a stage in our mental development, and is associated with definite past happenings, with actual events and moods and thoughts and wishes. . . .

"But what" (I can hear the reader say)—"what is all this about? What connection has it with living backwards?"

Its bearing upon the problem is this. Reversal of development led us on to resorption, resorption introduced us to the idea of differential susceptibility, and that again to systems built up as a hierarchy of dominant and subordinate parts.

But these, too, will show differential susceptibility; and so may prove capable of reversal of dominance. And, as a matter of fact, it comes about that even in the most highly-organised and complex system of all, in the system that underlies mind, such reversals of development may happen. It is not often that they happen; but the phenomenon is now well known, and goes by the name of "mental regression." Here the patient, as a result of "shell-shock" or other

form of neurasthenia, reverts mentally to a younger condition. In the case-records given by Nicoll, grown men behaved like boys of five or ten, played childish games, became dependent on their nurses like any child, and actually lived in the world of associations and memories they happened to have grown through in boyhood.

The most remarkable case of all has not, I believe, been put on record, but has been mentioned in public lectures by Dr. McDougall and Dr. Hadfield. An Australian soldier, already suffering from shell-shock, received a severe fright. As a result, the whole of his adult personality disappeared, and he became an infant—the mind of an infant in the body of a man. He could not talk properly, he could not walk properly, and, most amazing of all, he could not take any food but milk.

Gradually he grew up again, retracing in a year the mental development of a lifetime, and, on returning to his native country, has become, it appears, a normal adult being again.

Such mental regression differs of course from the regression of Perophora, in that the physical basis of the mental processes, the nerve-cells and fibres, are not resorbed or dedifferentiated during the backward passage; they simply lie fallow, rendered somehow unavailable for the passage of nervous activity. But in other ways the processes are essentially the same.

As new conditions rise and confront the growing mind (and minds may grow throughout life), the will must bend itself to adapting the mind to meet them. We all know what pain and grief this may be, and how readily we turn to distraction, or to memory, or to an ideal or an imaginary future to escape for a time from the struggle.

When present conditions grow difficult, as in war, or in grief or worry, it becomes harder and harder for the will to accomplish its proper task, more and more tempting for the mind to slip away to its imagined or remembered happiness. But this is differential susceptibility; and after a time, in people of certain temperaments, the strain on the higher, controlling centres gets greater and greater until at last they are not able to function so well as the alternative system, the approaches to which have been thrown wide by the mind's longing and conscious dwelling upon it. At last the one sinks, the other rises, till they are at a common level; a fraction more, and the flood of nervous energy pours out from the world of the present into the world of its own desire, its own phantasy. When its own desire is represented by memories of a happy past, the mind reverts to that past. To be accurate, the will is liberated from its task of controlling the hated present, and turns to the simpler and slighter measure of control which it once had to exercise; and with that degree and form of will come flying back all the associations of the time when it was in power. When the desire of the tormented present will has simply been to abandon all control, without necessarily envisaging any particular past time as most desired, then apparently we have the complete return to the uncontrolled state of the infant.

There we must leave the subject. It is a fragmentary tale that I have been able to tell; but our knowledge is fragmentary. At least it will begin to give some idea of the new vistas that biology is opening up. We have at any rate been able to assure ourselves that life can run backward, that reversal of development is a fact. Further, we see that reversal may show itself in several forms. It may be compatible with health and with normal function throughout, as in the Planarians; or, though recovery from it may be possible, yet reversal itself is only accomplished by a change to a simpler non-functional state, in which the organism can tide over hard times, as in Clavellina; or it may be (for the individual concerned) a pathological process, resulting inevitably in death, as in Perophora; or, finally, it may affect the mind without affecting the body, as in mental regression.

Such facts, among many others, make us feel that we are on the verge of a control of living matter which will make even our control of inorganic matter seem unimportant. The biology of to-day will look to our descendants as the chemistry and physics of Boyle and his contemporaries look to us. And the results will not merely be capable of changing our environment; they will be capable of changing us—our constitutions, our very natures. Let us hope that the thought of that time and the rulers of that time will be better fitted to make use of those discoveries than are the thought and the rulers of our own time to make use of the power that discovery has already put into their hands!

The Discoveries in Crete

By George Glasgow, B.A.

(*Concluded from January No., p.* 11)

IX

Cretan religion differed from that of classical Greece in that the chief deity worshipped was a goddess, Mother Nature or Earth-Mother, some at least of whose characteristics we find embodied in the Rhea of Greek mythology. Matriarchal religion seems to

have been specially characteristic of very early times; through it primitive man expressed his veneration of womanhood. The Cretan Mother Goddess holds an exalted position. She wields the supreme power over all Nature; is associated with doves, which symbolise her power in the air; is accompanied by lions, the strongest animals of the earth; brandishes snakes, that live under the earth. Among the various "cult objects," or ritualistic forms used in worship, found in her shrines are included representations of cows with calves, goats with suckling kids and the like.

There was a god as well as a goddess in Minoan religion, but he was of relatively little importance. Velchanos, the Cretan Zeus—if we may assume that the Minoan god was the original of this figure of the Greek legends—was represented as both the son and the husband of Mother Nature. He was suckled, so the tradition ran, by Amalthea the goat in the cave of Dikte, and brought up by his mother Rhea on the slopes of Mount Ida. His insignificance in comparison with the female deity appears from the fact that he was drawn on a smaller scale whenever represented in her company. The two deities probably constituted, as Mr. Hogarth has suggested, a "Double Monotheism"—a double godhead, that is, worshipped to the exclusion of all minor deities. If this was the case, the various Cretan prototypes of later Greek divinities must be regarded as variant forms of the Mother Goddess herself. Aphrodite, for instance, the goddess of Love, was worshipped generally in the Levant, being known in Canaan as Ashtaroth-Astarte, and in Egypt as Hathor; her Cretan name is unknown. The Greek Artemis, goddess of the Wild Beasts, was foreshadowed in the Cretan Dictynna.

One great difference between the Cretan and the Hellenic Zeus was that the Cretan Zeus was mortal, and was said to have died on Mount Juktas. The mortality of their gods was one of the striking conceptions which differentiated the Southern peoples of the Near East from the later Greeks, who came from the North. The Egyptian Osiris, for instance, could die, but not any of the Greek gods. The Cretan Mother Goddess is depicted on seal stones and rings dressed like an earthly queen, while Velchanos is seen descending from the heavens to the earth, a young warrior with a spear and an enormous shield.

Another difference between Cretan and classical Greek religion was that, as far as one can see, Cretan religion did not give rise to any great temples, nor did it leave behind any more substantial traces of its activity than the small figures of the Earth Goddess to whom I have referred. It may be sound to regard the palace of Knossos as itself a temple, and it is true that legend makes of Minos a High Priest as well as a King. There seems, however, to be little room for doubt that the only places set aside specifically for worship were small private shrines used for family worship. All the evidence tends to indicate that it was the family idea that predominated in Cretan worship. Private houses had their shrines, and the Knossian palace-temple itself had its lesser family shrines. These sanctuaries were always distinguished by a sort of sacred pillar, a sign which in Minoan art is often used as the only indication of a sacred place. There is an example of it on a fresco painting found at Knossos. Another emblem associated with the cult is that of sacred trees, which on rings and seal stones usually form the background for the *choros*, or dance. The actual dance, no doubt, would be performed in sacred groves.

Many cult-objects have been found in the shrines, the commonest being the mysterious Double Axe. The fact that this emblem was also specially associated with the Carian Zeus at Labraunda has led to a generally accepted theory that the Cretan "Labyrinth" corresponds to the Carian "Labraunda," or place of the "Labrus" or Double Axe; for the Knossian palace must have been, in fact, the chief seat of the cult.

Side by side with the Double Axe one finds the constantly-recurring sign of the Bull, an animal which was sacred not only because of its great physical strength, but also because of its use in sacrifice. A sarcophagus or coffin of terra-cotta, found at Hagia Triada, contains a picture of a sacrificial bull following a procession of women priests. In view of the prominence given to the Bull in Minoan worship, one need not seek very far for an explanation of the Cretan legend of the Minotaur, a monster half man, half bull, which lived in the labyrinth and exacted its human victims. Nor is it impossible that the dangerous and cruel sport of bull-fighting [1] formed part of the same cult. Bulls' heads were made in pottery and used as votive offerings, and were sometimes made of gold. The horns of the bull—Horns of Consecration—are found in shrines among ritual objects.

Cult-objects were usually of a rude and inartistic kind, a striking exception to the general rule being afforded by some brilliantly-coloured figures of ware which if it were modern would be called "faïence," belonging to the M.M. III period. Perhaps the best example of this ware is a group consisting of the Snake Goddess and her votaries, which was found by Sir Arthur Evans in 1903, and which was used in a shrine of the royal household.

There was a specially important element in Cretan religion reserved for the cult of the dead.

It is obvious, from the many tombs that have been excavated, that in very early times it was the practice

[1] See DISCOVERY, August 1920, p. 249.

to bury the body of the dead in a doubled-up position, the knees being drawn up to the breast. In later times the body was laid out at full length. It is not clear whether or not there was any particular significance in this choice of position. There were various kinds of tombs and graves, all of which were used contemporaneously, and of which, perhaps, the most interesting were the *tholoi*. The word *tholos* properly means a domed building or rotunda, and the particular kind of tomb to which it is applied is a vaulted chamber to which entrance is effected through an underground tunnel, or *dromos*. It is conceivable, indeed almost certain, that in form these *tholoi* were based upon the huts used—at some period—by the living. There are both round and square *tholoi* found in Crete. The *tholos* of Hagia Triada has a circular ground plan, while the Royal Tomb at Isopata and other elaborate tombs of the great palace-periods are rectangular. The principle of the tholos-tomb was most in use in Mycenæan times, on the mainland of Greece, where the "beehive tombs" almost all retained the original round formation. The hilly character of Crete led the people to cut out their *tholoi* in the side of the rocky hills, the *dromos*, or tunnel, in this case being driven into the hillside almost horizontally.

Another style of grave was the shaft- or pit-grave, which consisted of a pit sunk into the ground, at the bottom of which was the grave itself, closed over with slabs of stone. Still another kind was a combination of the first two, and is known as the "pit-cave." This was made by first sinking a pit and then cutting out the tomb in the form of a side-recess from the bottom of the pit. A simpler form of burial, known as the "pot-burial," was effected by trussing up the body, placing it under an inverted jar, and then burying it in the earth. A sixth form was that of the simple grave, like our own. Cremation was not practised in Minoan times, although it was introduced into Crete from Greece in the Iron Age. Clay coffins were first used in the Middle Minoan period, being made in the form of deep boxes with sloping tops resembling the roofs of houses.

Such were the physical conditions of burial. We knew practically nothing of the cult of the dead until Sir Arthur Evans published some new and enlightening disclosures six years ago.[1] It was known before that the dead in their spacious tombs were honoured with gift-offerings, which included weapons, jewellery, and objects closely associated with them in their life; that food and drink offerings were made and coals of fire lighted, possibly with the naïve or symbolic object of cheering the traveller on his mysterious way. Now, however, a new series of tombs has been found at Isopata, one of which, called by Sir Arthur Evans "the Tomb of the Double Axes," is proved to be not only a tomb, but a shrine of the Minoan Great Mother. In this tomb were found libation vessels, including a *rhyton* (or drinking-cup) in the shape of a bull's head made of steatite, and a pair of double axes; the grave which received the body is cut out in the form of a double axe. "The cult of the dead," says Sir Arthur Evans, "is thus brought into direct relation with the divinity or divinities of the Double Axes, and we may infer that in the present tomb the mortal remains had been placed in some ceremonial manner under divine guardianship."

[1] *Archæologia*, 2nd series, vol. xv, 1913–14.

X

When Knossos fell, Crete ceased to be the pre-eminent power in the Near East. The island itself was overrun by military or naval adventurers, and the centre of Mediterranean life shifted over to the mainland of Greece, whence, indeed, those adventurers came. The striking thing, however, was that Cretan culture went with it, and neither for the last, nor probably for the first, time "the captive led captive her savage conqueror," as Horace wrote centuries afterwards. Crete stooped to conquer Greece, just as Greece in her turn stooped to conquer Rome.

The Cretans as a race were quite distinct from the contemporary inhabitants of Greece. Physical types were sharply divided by the shores of the mainland. The critical reader may ask: "Is it worth while to speculate as to the physical characteristics of a people which flourished 4,000 years ago, whose very existence was obscured by the Dark Age that comes before Greek history, and whose existence was not rediscovered until, so to speak, the other day?" And yet archæology works wonders. It is true that in this particular field, in which archæology is chiefly dependent upon portrait-paintings and bones, there is more controversy and less certitude than in the others; and that craniology, or the study of skulls, with their much-disputed classification into "brachycephalic" or broad-headed, "dolichocephalic" or long-headed, and "mesocephalic," midway between the two, is a fruitful source of confusion; that the "cephalic" index—that is, the breadth of the skull above the ears expressed in a percentage which gives the proportion of this breadth-measurement to the measurement of the length of the same skull from the forehead to the occiput—is a very poor index of anything at all. Still, there is ground for assuming that from the later Stone Age onwards the islands of the Ægean were mainly peopled by members of the "Mediterranean" race, small of stature, with oval faces, with perhaps rather long heads—if that means anything—

with small hands and feet, with a dark complexion and with dark eyes and black curly hair.

According to Professor J. L. Myres in his *Dawn of History*,[1] the north-west quadrant of the Old World resolved itself racially into three belts, which were determined by geographical conditions. In the north were the pure white-skinned "Boreal" men of the Baltic basin; next came the sallow "Alpine" type; then the red-skinned "Mediterranean" man. The third was an intruder from the South, not far enough south for him to be a negro, but probably from the northern shores of Africa. His intrusion "formed part of a much larger convergence of animals and plants from the south and south-east into the colder, moister regions which have been released since the Ice Age closed." The limit of the movement seems to have been fixed by the shores of the mainland, because the lungs and constitution of the people concerned were unable to endure any further cold.

The establishment of the existence of the Mediterranean race has had, among other results, that of making it no longer possible, as was invariably the practice before Crete was excavated, of ascribing all obscure factors in the beginnings of Greece to a Phœnician origin. We now know, for instance, that the art of writing came from Crete, Phœnicia being the medium. We know now that Phœnicia was merely a late centre of the general Ægean civilisation, and was specifically called by the name because it was the best-known branch of the "red-skinned" race; for "Phœnikes" literally means "Red-skins," and in Homer Phœnix himself is a King of Crete and grandfather of Minos.

The Minoan people, then, formed part of the Mediterranean race. Their dress was much simpler than that of the classical Greeks. The men wore a short pair of drawers or a loin-cloth, the upper part of the body being bare as in the cup-bearer picture (January DISCOVERY), a style emanating, as did the men themselves, from the warm lands south of the Mediterranean. Egyptian fresco-paintings reveal an almost exact analogy of type in the clothing and appearance of the Egyptians. Those who have a keen eye for the persistence of type may perhaps be interested to compare some of the forms of loin-cloth, as depicted on seal stones, with the *brakais*, or baggy breeches, still worn in Crete. Elders and officials apparently wore the added dignity of flowing cloaks. High-topped boots—again suggestive of those worn to-day—were in general use. Men wore their hair long as did the women, plaited and coiled up on the top of the head, thereby forming the only headdress that was used.

Minoan war-equipment was severely limited. Their only weapons were a long sword and a dagger, the latter of which is shown by pictures of clay figurines to have been carried inside the belt at the front. Their only armour of defence was a big shield of leather and a leather conical helmet. The shield was framed in a metal band, but had no handle or central boss; it was big enough to cover the body from head to foot, and it could be bent so as to protect both sides. It is represented in certain pictures in a curious 8-shape, pinched-in in the middle. The origin of this may have been that it was the practice to sling it over the left shoulder suspended by a strap, and for this purpose the figure-of-eight shape may have been convenient.

Horses apparently were used both in war and in hunting, although we have no pictures of them being ridden. The available evidence shows them only in the shafts of two-wheeled chariots. This accords well with Professor Sir William Ridgeway's observation (made far back in the eighties of last century) that in Homer the horse was driven only, and no bigger than our donkey. There is reason for thinking that the horses were imported, and imaginative people have recognised evidence of this in the fact that a seal stone has been found which shows a horse on board ship. Whether intentionally or merely from crudity of draughtsmanship, one is left in little doubt as to what mostly occupied the artist's mind when he fashioned this stone, for the horse covers three-quarters of the ship's length, and towers high above it, while the crew stand as high as the horse's knees.[2]

The women are readily distinguishable from the men in Cretan pictures by reason of their white skin, suggestive of a more secluded indoor life. They wore large shady hats, close-fitting, puffed-sleeved blouses, cut very low in front, and projecting upwards into a sort of peak at the back of the neck. They wore wide-flounced, richly-embroidered skirts like crinolines, and had belts like the men's. A French scholar, on first seeing some of the pictures representing Minoan women, was so taken by surprise that he exclaimed: "Mais ce sont des Parisiennes!"

Minoan women enjoyed a far more "advanced" status than did other primitive women. In the art of their day they are represented as appearing in public and unveiled; they took part in the bull-fighting at Knossos, and their apartments in the palace were marked out by their special luxury. The greatest glory for an Athenian woman of a later age was to be "as little mentioned as possible among men." Not so for the women of Crete. There may be significance in the fact that the Lycians of Asia Minor, who

[1] Pp. 39 *et seq.* Williams & Norgate, 1912.

[2] On the fascinating subject of the history of the horse, the reader should consult Sir W. Ridgeway's *Origin of the Thoroughbred Horse* (Cambridge University Press, 1905).

were colonists from Crete, made a practice of calling children by the mother's, not the father's, name.[1] If this was the case also in Minoan Crete itself, it may afford a possible explanation of the freedom enjoyed by Cretan women; for the practice of naming children after their mother instead of after their father is connected with states of society which have not yet evolved any definite ideas of marriage, and in which, as Herbert Spencer says, "The connection between mother and child is always certain, whereas the connection between father and child would sometimes be only inferable."

XI

Towards the end of the Minoan Age Cretan culture began to spread all over the Ægean, and extended to the mainland. Cretan vases are found as far north as Bœotia, and the many Cretan relics discovered in Mycenæan tombs were not all war-souvenirs; some of them, belonging to times before the fall of Knossos, were the peaceful product of Cretan workmen who had been induced by the Lords of Mycenæ to emigrate.

The men from the North who finally overthrew what we call the Minoan civilisation, became to some extent the repositories of Cretan tradition. They carried on a less splendid phase of Cretan civilisation, a phase which was distinguished by the name "Mycenæan." They had come to Greece from lands still further north, whence they had themselves been driven to seek new homes. They came down in successive waves of invasion, the men who formed the first wave being known as the "Achæans," the "yellow-haired Achæans" of Homer. It was they—so at least some authorities hold—who sacked Knossos, and who afterwards, during the thirteenth and twelfth centuries B.C., wandering about in search of adventure, became the terror of the whole Ægean. An Egyptian inscription of those times says: "The Isles were restless: disturbed among themselves."

Egypt herself felt the effect of the disturbances. From the "isles in the midst of the Great Green Sea," there no longer came the peaceful Minoans to pay their friendly tribute to Egypt's King; instead there came the unpeaceful Achæans, on an unpeaceful mission. Two raids were made—if we may trust the students of Egyptian records[2]—one about 1230 B.C., another about 1200 B.C. Not long after we find the Achæans, in Agamemnon's famous expedition, fighting against the Trojans in Asia Minor; and they took the city at last in 1184 B.C., if we accept the date supported by the weight of Greek tradition. It is their deeds in the latter war that have been sung by Homer. Two generations after the Trojan War, shortly before 1100 B.C., Greece was overrun by the Dorians, who formed the second great wave of Northern invaders. After that came the Dark Age, out of which about 800 B.C. emerged classical Greece.

Classical Greece was the fusion of the two main elements of prehistoric times, the artistic Mediterranean people on the one hand, and the robust Northern invaders on the other. Just as the fusion was probably consummated in the Dark Age, so the first poet of classical Greece, Homer, whether one person or the embodiment of many, heralded their new life in song which seemed to echo from that Dark Age, but of which the substance was probably far less legendary than historical. Whether the traditions of the Minoan Age in Crete were kept alive through the Dark Age in Ionia, whither it is thought that they were carried by Achæan refugees at the time of the Dorian invasion, which extended to Crete, or whether they remained dormant in Crete itself, and in the Mycenæan centres of the mainland of Greece, it is in either case certain that they were abundantly preserved, for their traces are plainly to be seen throughout Greek civilisation. And from the Greek writers they descended as a treasured heritage to the poets of Rome, and so to the art and literature of Europe.

[1] Herodotus, i. 73.

[2] See H. R. Hall, *The Ancient History of the Near East*, p. 70 (Methuen, 1913). Mr. Hall gives the more definite date of *c.* 1196 for the second invasion.

The Structure of the Universe

By the Rev. Hector Macpherson, M.A., F.R.A.S., F.R.S.E.

(*Continued from January No., p. 8*)

II. Twenty Years of Progress

So far as astronomical science is concerned, the twentieth century bids fair to be the "wonderful century." In no other period of equal length as the two decades since 1900 has the rate of progress been so rapid. All branches have gone forward, in greater or less degree; but in none of the sub-sciences into which astronomy is now divided has so much been accomplished as in the department relating to the structure of the stellar universe. There have been various reasons for this rapid advance. The present generation has come into a great heritage—the accumulated

observational treasures of the past two centuries, which Dr. Abbot has called "that precious store of exact knowledge whose value time cannot impair, but can only enhance." The observations of Bradley, for instance, become more precious with the passage of the years; so do the tabulated surveys of the Herschels, of Bessel, and of Argelander and Schönfeld, the photographic surveys of Gill, and the pioneer spectroscopic work of Secchi, Vogel, and Pickering. The nineteenth-century astronomers were largely occupied in amassing observations; in the twentieth, we are, in some measure at least, reaping the fruits of their labours. A second factor in the remarkable progress of this branch of astronomy is the rapid development of the powers of the telescope—and consequently of the spectroscope—during the last thirty years. The great refractors of the Lick, Lowell, and Yerkes Observatories in the United States have been employed—the two former in superb climates—with the highest advantage to stellar astronomy. More recently the great reflectors of Mount Wilson have carried us still further into the depths of space.

As remarked in the previous article, astronomers in the nineteenth century were obliged to concentrate on the study of stellar distribution; comparatively few stellar distances and motions had been determined with accuracy. By the opening years of the century, however, it was evident that the investigation of stellar motion was to prove a valuable line of attack on the ultimate problem. In 1904 Professor Kapteyn, of Groningen, read at the Astronomical Congress at St. Louis, U.S.A., a paper of far-reaching importance, in which he announced the discovery of star-streaming. As is well known, there are two components in the motion of each star: (1) the parallactic motion due to the movement of the sun, carrying with it the earth and the other planets, and (2) the individual proper motion. Formerly it was believed that after the parallactic motions were eliminated the individual motions were more or less at random. This assumption Kapteyn showed to be erroneous. After eliminating the parallactic motion from the motions of the bright stars in the catalogue of Bradley, revised by Auwers, Kapteyn found that the motions of the stars fell into two opposite directions in the galactic plane. This result he interpreted as indicating that the brighter and nearer stars belong to one or other of two vast interpenetrating star-streams.

Shortly afterwards these results were abundantly confirmed by the independent work of Professor A. S. Eddington, then chief assistant at Greenwich, now director of the Observatory at Cambridge. In his first paper on "The Systematic Motion of the Stars," read before the Royal Astronomical Society in November 1906, Eddington made what he called "the attempt to subject Kapteyn's theory to a quantitative test by examining the Greenwich-Groombridge proper motions. The following reasons, among others, seemed to make this desirable. The Bradley stars are all bright stars; of those of the Groombridge catalogue a large number fall between the seventh and ninth magnitudes. The 2,500 stars of Bradley's catalogue cover most of the sky; the 4,500 stars of Groombridge are all within 52° of the north pole." The result of the investigation was a complete confirmation of Kapteyn's theory. Eddington ascertained that the velocity of the first drift of stars relative to the sun was very much greater than that of the second, and that there was no appreciable difference in the main distances of stars of the two drifts.

A further stage was reached by the paper which Sir F. W. Dyson—then Astronomer-Royal for Scotland—read before the Royal Society of Edinburgh in 1908. His investigation covered 157 stars within 52° of the north pole, taken from Groombridge's catalogue; 165 stars within 50° of the South Pole from the Cape Astrographic Catalogue, from Porter's Cincinnati Catalogue, and the Cape General Catalogue; and 778 stars within a belt extending 30° north and south of the equator, from the Cincinnati Catalogue. The results of this study of stars, scattered all over the sky, were strongly in support of the two-drift hypothesis. "The quick-moving stars here considered show the streams in a very pronounced light." Confirmation of the two-stream theory was also forthcoming from Professor Campbell's investigation of radial motion. Dr. Halm, of the Cape Observatory, not only confirmed the hypothesis by his own researches, but came to the conclusion that there were not only two drifts, but three.

Various hypotheses were put forward to explain the existence of the two star-streams. Local streams had, of course, been known since Proctor pointed out the community of proper motion of five of the stars of the Plough; but the work of Kapteyn, Eddington, and Dyson indicated that the great mass of the brighter stars belonged to two or three streams, and this called for a theoretical explanation. The problem before the theoretical astronomer was to preserve the unity of the universe. In 1908 Schwarzschild, of Potsdam, put forward his ellipsoidal hypothesis, and in 1912 Turner, of Oxford, outlined a new theory reconciling the observed duality of the universe with the unity which theory seems to demand. In 1911 Eddington remarked, however, that "the two star-streams probably involve at least half a million of the stars around us; but there has never been any evidence that they prevail in the extremely remote parts." This has been confirmed in recent years, and the two-drift phenomenon finds its explanation in the

comprehensive cosmological scheme of Dr. Harlow Shapley.

Since the opening of the century, various new methods of determining the distances of stars have been devised; and in this way it is now possible to speak with some degree of confidence of the scale on which the universe is built. In the first place, Kapteyn, as early as 1901, indicated the possibility of ascertaining the mean parallaxes of groups of stars. Secondly, Dr. W. S. Adams, at Mount Wilson, found some years ago that the intensities of certain lines in stellar spectra depend on the absolute luminosity of the stars, and as a result he has been enabled to measure the distances of hundreds of stars by the spectroscope, and thus to add enormously to our knowledge of exact stellar distances. Thirdly, Professor H. N. Russell, of Princeton, from his study of "eclipsing-variable" stars, was able to ascertain the absolute

THE STAR-CLOUDS OF THE GALAXY IN THE DIRECTION OF SERPENS AND SAGITTARIUS.
(From a photograph by Professor Max Wolf.)

magnitudes and thus to compute the parallaxes of nearly a hundred of these. Fourthly, in the large class of variables known as Cepheids, the length of the period of variation has been ascertained to depend on the absolute brightness. The mean parallaxes of the nearer of these variables being known, it is possible to determine the absolute magnitude, and thus the distance of every Cepheid variable in the heavens. Finally, Russell and others have indicated theoretically a method of ascertaining the minimum distance of the bright helium stars of type B. Only stars of very large mass are able to attain to the unusually high temperature of B-type stars ; hence a B-star, however faint it may appear, must have a certain minimum absolute magnitude. All these new methods of determining and estimating distance have contributed to a great extension of our knowledge of the extent and structure of the universe. Further, in recent years it has become possible to ascertain the hypothetical spectral type of the very faint stars. As is well known, the photographic plate is more sensitive than the eye to certain wave-lengths of light ; the difference between the photographic and the visual magnitude of a star is therefore due to the colour of the star, and is called the colour-index. Thus it is possible to determine the colour, and hence the approximate spectral type, of very faint stars whose spectra cannot be directly observed.

As a result of these new methods of investigation several researches of the utmost importance have been undertaken within the last few years. In 1916 Professor Charlier, of Lund, published a paper on " The Galaxy of the B-type Stars," in which he started from the assumption that the B-stars do not differ much in absolute magnitude. Having made this assumption, he was enabled to determine the distances of stars of this type brighter than the fifth magnitude. He found that these stars form a well-defined flattened cluster—whose plane is very similar to that of the Galaxy—with its centre of gravity in the constellation Carina. The farthest limits of the cluster Charlier found to be at a distance of 750 parsecs [1]—roughly corresponding to about 2,000 light-years. " We are," said Charlier, " in a position to get, with the help of the B-stars, what might appropriately be called a skeleton image of the Milky Way." In other words, Charlier assumed that the system of B-stars was co-extensive with the stellar universe.

In 1913 Professor Hertzsprung, of Potsdam, from a study of the Cepheid variable stars in the Lesser Magellanic Cloud, estimated the absolute magnitudes of these stars, and thus their distances and the distance of the cluster. The distance at which he arrived was 10,000 parsecs—corresponding to about 30,000 light-years. In the following year Dr. Harlow Shapley, the brilliant American astronomer, commenced, with the aid of the great 60-inch reflector of the Mount Wilson Observatory, his studies on the colours and magnitudes in stellar clusters. The clusters investigated were of two classes, the compact globular clusters and the open galactic clusters which are undoubtedly condensations of distant Milky Way stars. The results reached by Dr. Shapley during the first two years of his investigation were sufficiently startling. In the galactic star-clouds in the vicinity of the open cluster Messier 11, he discovered faint blue stars obviously of type B. " The cluster-stars," wrote he in April 1917, " are probably giants in luminosity, and accordingly the distance of the group must be of the order of 15,000 light-years. The wide dispersion in magnitude of both blue and red stars indicates a similarly great distance for the neighbouring galactic clouds. It suggests that the extent of the stellar clouds in the line of sight is relatively very great—in fact, the depth may be as great as, or greater than, the distance to the nearer boundary."

No less remarkable were Shapley's preliminary conclusions regarding the brighter globular clusters. The first of these exhaustively studied was the great cluster in Hercules (Messier 13). In his paper on this cluster, dated August 1915, Shapley estimates its distance from " considerations of its variable-stars, its fragmentary luminosity-curves, and the average apparent brightness of certain colour groups," as 100,000 light years, a distance much greater than had ever been imagined for the cluster.[2]

Dr. Shapley's subsequent researches have been given to the world in the series of " Contributions from the Mount Wilson Observatory," and have been admirably summarised in his recent pamphlet on " Star-Clusters and the Structure of the Universe." By means of the various methods of determining absolute magnitude and distance, Shapley has fixed the positions in space of eighty-six globular clusters. He finds these to be " cosmic units," sub-systems dependent on the greater galactic system, at enormous distances from our earth. The nearest, Omega Centauri, is 20,000 light years away, and the most distant—known as N.G.C. 7006—is so distant that light requires 220,000 years to travel from the cluster to the earth. Shapley finds the clusters arranged in a certain symmetrical way, which indicates that they are dependents of the sidereal system—as Professor Perrine suggested in 1917—and that the sun is not near the centre of the universe, as was generally

[1] The parsec is the distance which corresponds to a parallax of one second of arc. It is equal to nineteen billions of miles.

[2] A later measure by Dr. Shapley gives a distance of 36,000 light-years.

believed. Shapley's researches indicate that the centre of gravity of the sidereal system is in the constellation Sagittarius, amid the dense star-clouds of that region, 60,000 light-years from the sun. The stellar system itself is seen to be much vaster than has been hitherto believed. "The study of the distances and structure of globular clusters has shown that in volume the galactic system is more than a hundred thousand times as large as we formerly believed it to be"—at least 300,000 light-years in diameter. "The phenomenon of the Milky Way is largely an optical one. Although the existence of local and occasionally very extensive condensations of Milky Way stars is not denied, the conception of a narrow encircling ring is abandoned. The Milky Way girdle is chiefly a matter of star-depth, and its long-recognised weakness between longitudes 90° and 180° is now taken to be a reflection of the eccentric portion of the sun." The system is vastly more extended in the galactic plane than in the direction of the poles. "A thin central stratum of the galactic segment contains every star that has been seen or has been photographed for our catalogues. This stratum of stars apparently deviates less than two thousand light-years from the galactic plane." In other words, Shapley's researches show the sidereal system to be a flattened disc, about 4,000 light-years in thickness and 300,000 in diameter. We have reverted, therefore, in great measure to Herschel's standpoint and to Herschel's conception of the vastness of interstellar space. Grouped round about the sidereal system are the subordinate clusters which Shapley believes to be gradually falling into the larger system, which is, in fact, an assemblage of absorbed clusters. He considers the stars in the vicinity of the sun—including Charlier's galaxy of B-type stars which that astronomer thought to be co-extensive with the universe—to form a local cluster—a striking confirmation of the theory put forward years ago by B. A. Gould. The interpenetration of this cluster with the general galactic stars gives rise to star-streaming, which is, as Eddington maintained ten years ago, a local phenomenon confined to the stars in the vicinity of the sun.

Such, then, is the vast universe which Dr. Shapley's researches have revealed to man—a universe so vast that the mind is staggered by its contemplation. Is it the only universe? During the past decade the fascinating theory of "island universes" has been revived in a new and plausible form. In November 1911 Professor F. W. Very put forward the view that the faint white nebulæ were not actually gaseous, but distant stellar systems—island universes, of which the smallest and faintest was a million light-years away. In 1912 Dr. V. M. Slipher commenced, at the Lowell Observatory, his measures of the radial velocities of the spiral nebulæ. Grave doubts had already been thrown by spectroscopic evidence on the supposed gaseous nature of these nebulæ—the spectrum of the typical spiral being continuous. Slipher's investigations indicated that "the average velocity of the spirals is about twenty-five times the average stellar velocity." This differentiates them from the ordinary nebulæ; so does the peculiarity of their distribution. Unlike the planetary and irregular nebulæ, they avoid the galactic regions, and are most numerous near the galactic poles. These facts seemed to emphasise the

THE GREAT SPIRAL NEBULA IN ANDROMEDA.
(*From a photograph by Ritchey, of the Yerkes Observatory.*)

non-nebular, extra-galactic nature of the spirals, and accordingly many of the most eminent astronomers—such as Eddington and others—have been disposed to look favourably on the "island universe" hypothesis. The Messrs. Lindemann, in their recent preliminary application of photo-electric photometry to astronomy, have reached an estimate of the distance of the Andromeda nebula, the greatest of the spirals. They find it to be distant 350,000 parsecs, or a little over 1,000,000 light-years, maintaining that there is "nothing inconsistent in regarding this nebula as a galaxy very similar to our own."

The recent work of Shapley, however, would seem to indicate that, whatever the spirals are, they are not of equal status with the galactic system. He regards

them as one of two types of organisation in extra-galactic space—the evidence suggesting that the "galactic system now moves as a whole through space, driving the spiral nebulæ before it." Repulsion, not gravitation, appears to be the ruling power so far as the spirals are concerned. "Is it possible," asks Shapley, "that the spirals represent the failure to form stars from the original condensing nebulosity through the presence of too much material?" The spirals, he suggests, may be composed of "particles of molecular dimensions peculiarly susceptible to the pressure of such radiation as is emitted by the stars." If this be so, the spirals may be said to represent the waste material of the universe, and to be in a sense analogous to the cometary and meteoric matter within the solar system.

Whatever be the status of the spirals—whether or not they indicate the existence of many systems coequal with the vast sidereal organisation in which our sun is but a dwarf star—there can be no doubt that the recent progress of astronomy has enormously widened our mental horizon, having revealed a sidereal system so vast that we are powerless to grasp its immensity—a sidereal system which dwarfs to utter insignificance the tiny globe on which we live and the tiny star round which that globe revolves. "Such," to quote the words of Flammarion forty years ago, but more applicable to-day than when they were written, "is the aspect, grand, splendid, and sublime, of the universe which flies through space before the dazzled and stupefied gaze of the terrestrial astronomer, born to-day to die to-morrow on a globule lost in the infinite night."

BOOKS FOR FURTHER READING

Collected Scientific Papers, by Sir William Herschel.
History of Physical Astronomy, by Robert Grant.
The Universe of Suns, by R. A. Proctor.
The Visible Universe and the *Concise Knowledge of Astronomy*, by J. E. Gore.
The Stars, by S. Newcomb.
Stellar Motions, by W. W. Campbell.
Stellar Movements and the Structure of the Universe, by A. S. Eddington.
Studies based on the Colours and Magnitudes in Stellar Clusters, in "Contributions from Mount Wilson Observatory," by Harlow Shapley.

The Elder Edda and Ancient Scandinavian Drama. By BERTH S. PHILLPOTTS, Litt.D. (Cambridge University Press, 21*s.*)

The Groundwork of Modern Geography. By ALBERT WILMORE, D.Sc. (G. Bell & Sons, 6*s.*)

A Dictionary of Scientific Terms. By I. F. and W. D. HENDERSON. (Oliver & Boyd, 18*s.*)

"The Winter's Tale" and its Source

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THE earliest proofs of Shakespeare's popularity as a dramatist date from 1592. And the most convincing, though not the first or the sweetest, was Greene's ill-natured death-bed warning of that year to his fellow-playwrights. "There is," wrote Greene in *A Groatsworth of Wit bought with a Million of Repentance*, "an upstart Crow, beautified with our feathers, that with his Tyger's heart wrapped in a player's hide supposes he is as well able to bumbast out a blanke verse as the best of you; and being an absolute Johannes Factotum is, in his owne conceit, the only Shake-scene in a countrie." Greene's was not a generous nature: applause was meat and drink to him; and he loathed the very suspicion of a rival. Least of all could he bear to be put down by a Shakespeare—by a man who had never known a University, a mere player who dared to emulate his betters. But it is doubtful if others shared Greene's envy. Before the year was out, Greene's publisher tendered an apology, in which he confessed the young Shakespeare's "demeanour no lesse civill than he excelent in the qualitie he professes," and praised "his uprightnes of dealing, which argues his honesty, and his facetious grace in writing that aprooves his art."

How Shakespeare himself regarded the incident we cannot know for certain. There is nothing to show that he hated Greene in return. Yet some have thought that Shakespeare felt the attack keenly and never forgave it, though Greene had died almost as soon as his libel was uttered. Shakespeare took his revenge, they say, in *The Winter's Tale*—a play written in 1611, some nineteen years later, and probably the last which he made alone. It is a strange coincidence, no doubt, that in the evening of life when he thought to retire from the theatre and all its business, Shakespeare should choose a story of Greene's to supply him with the matter for a last play. But need we infer that there was any spiteful motive in the choice merely from the fact that Shakespeare's version surpasses Greene's? Other tales by other writers had been borrowed in the same way and been so far improved that the original was quite forgotten. And, after all, Shakespeare has not destroyed Greene's story utterly: one or two passages, and those the best, he has spared untouched. Their preservation may suggest a better motive than malignity on Shakespeare's part. The manner of

their preservation offers a pleasant field in which to study his methods of composition.

Greene's story was called *Pandosto, the Triumph of Time*, and was published in 1588. In the next century it was renamed by the booksellers, less appropriately, as *The Pleasant History of Dorastus and Fawnia.* It may be summarised as follows: Egistus, King of Sicily, visits Pandosto, King of Bohemia (a sea-coast country as in Shakespeare's play). Pandosto grows suddenly jealous of his guest and of his own queen Bellaria. Egistus, with the aid of the cup-bearer Franion, escapes. But Bellaria, accused by her husband and brought to trial, learns, as a climax to her griefs, of the death of her only son Garinter, and dies in court. Meanwhile, her new-born daughter Fawnia, set adrift upon the sea, has been carried by the waves to Sicily, where she is found and nurtured by an old shepherd and his wife. Prince Dorastus of Sicily, Egistus' son and heir, is presented to us as a contemner of love. Revolting against his father's proposal to marry him to a Danish princess, one day, as he returns from hawking, he sees Fawnia; falls in love with her at once; and, before his father can learn of the attachment, escapes with her on board ship—carrying along with him the old shepherd, to prevent discovery. The ship is driven by storms into Bohemia, and the lovers in disguise reach Pandosto's court, where Pandosto falls grossly in love with his own daughter. When at last Egistus tracks his son's whereabouts, and the truth is made plain to all concerned, Pandosto kills himself in despair for his sins.

If now we compare this with the events of Shakespeare's play, it would appear that the divergence from Greene is not remarkable till we reach the second part of the story, concerning the loves of the princes. In other words, the opening scene of the fourth act of *The Winter's Tale*—the speech of Time as Chorus, announcing the silent passage of sixteen years—not only marks a break in the plot, but divides the play conveniently for our purpose of comparing it with its source. The two parts separated by this scene have been differently rebuilt.

Let us confine ourselves for the moment to the first part. The impression conveyed by these three acts to anyone who knew the novel well and was reading the play for the first time, would naturally be that Shakespeare was simply translating a piece of narrative into dramatic form. The interest of the story may be more keenly felt; the characters may be presented more vividly and with surer touch, as well as under new names—that was to be expected. But throughout this part there is nothing to warrant the expectation of a *dénouement* other than that of the novel. The story of Leontes' jealousy of his queen, Hermione, and his friend, Polixenes; of the friend's escape and the queen's imprisonment; of Perdita's birth in prison and her abandonment to the mercies of the sea; of her mother's trial and acquittal, thanks to an answer given by the Oracle of Apollo; of the death of Leontes' sole heir, Mamillius; and of Leontes' grief and repentance—all this is retold from the corresponding part of Greene's novel. Incidents of the original which are not actually reproduced, we shall find, none the less, preserved by being mentioned in this or that speech; if some new character is added, we shall find that the requirements of a drama sufficiently explain the change. Thus the trial scene of Hermione (III, 2) does duty for the two appearances in court of her prototype Bellaria; and

GREENE IN HIS SHROUD COMPOSING.
(*From "The English Novel in the Time of Shakespeare," by J. J. Jusserand.*)

so Shakespeare makes Leontes send to consult the Oracle on his own initiative, not (like Pandosto) at the request of his queen on her first appearance before her judges. Drama often needs thus to compress a story which there is room in a narrative to expand. Again, in the first scene of all, Archidamus—Shakespeare's own creation—is introduced merely to gather up in dialogue with Camillo, the opening passages of the novel, to define the starting-point of the play. And so of all the slight divergences from the plot of the novel in these first three acts, we may say with truth that they are due to the requirements of drama, save perhaps in two instances—the additions, namely, of the characters of Antigonus and of his wife Paulina.

Paulina's function in the play is really to bring about a conclusion quite different from that of the novel; at her home, Hermione will be hidden to

await the final reconciliations. But this is about the last thing we learn in Shakespeare's management of the story—the first hint of such a purpose being given only in the fifth act. To one who has read no further than the close of the first part of the play, she is simply a woman whose tongue (as she expresses it) is " trumpet " to her " red-look'd anger." Shakespeare, that is, had to give in speech what Greene renders by a plain statement—that the nobles and court generally were troubled to see their king so unreasonably jealous ; and that their protests helped at least to dissuade him from his first intention of burning to death both his queen and the daughter she had borne in prison. Hence Shakespeare invents this woman with a tongue and her respectful husband. The reason for creating both—so far as one might gather from the first three acts—was simply that the opposition of the court to the frenzy of Leontes might be effectively voiced. They are born, so to speak, of the essential difference between drama and narrative.

This explanation of the appearance of Paulina, as we have seen, is really incomplete, if we are dealing with more than the first acts of the play. No such qualification is called for in Antigonus' case. Yet Antigonus gives rise to the first remarkable alteration of Greene's plot by Shakespeare ; and until we come to the second part it is the only one that could possibly rouse even a suspicion of any other motive than the dramatisation of the plot. I refer to the last scene of the first part, the abandonment of Perdita on the coast of Bohemia.

For clearness' sake Greene's account of the rescue must be quoted at length. Fawnia (Perdita) was set adrift by her jealous father, Pandosto (Leontes), in " a little cock-boat." Tempest-tossed for " two whole days . . . at last . . . the little boat was driven with the tide into the coast of Sicilia " [Shakespeare reverses the scenes] " where sticking upon the sands it rested." The narrative then continues as follows [1] :

" It fortuned that a poor mercenary shepherd that dwelled in Sicilia, who got his living by other men's flocks, missed one of his sheep ; and, thinking it had strayed into the covert that was hard by, sought very diligently to find that which he could not see ; and fearing either that the wolves or eagles had undone him (for he was so poor that a sheep was half his substance), wandered down to the sea cliffs to see if perchance the sheep was browsing on the sea ivy, whereon they greatly do feed ; but not finding her there, as he was ready to return to his flock he heard a child cry ; but knowing there was no house near, he thought he had mistaken the sound and that it was the bleating of his sheep. Wherefore, looking more narrowly, as he cast his eye to the sea he spied a little boat, from whence, as he attentively listened, he might hear the cry to come. Standing a good while in a maze, at last he went to the shore, and wading to the boat, as he looked in he saw the little babe lying all alone ready to die for hunger and cold, wrapped in a mantle of scarlet richly embroidered with gold, and having a chain about the neck.

" The shepherd, who before had never seen so fair a babe nor so rich jewels, thought assuredly that it was some little god, and began with great devotion to knock on his breast. The babe . . . began again to cry afresh, whereby the poor man knew that it was a child, which, by some sinister means, was driven thither by distress of weather ; marvelling how such a silly [i.e. innocent] infant, which by the mantle and the chain could not be but born of noble parentage, should be so hardly crossed with deadly mishap. The poor shepherd, perplexed thus with divers thoughts, took pity of the child, and determined with himself to carry it to the king, that there it might be brought up according to the worthiness of birth, for his ability could not afford to foster it, though his good mind was willing to further it. Taking therefore the child in his arms, as he folded the mantle together the better to defend it from cold, there fell down at his foot a very fair and rich purse, wherein he found a great sum of gold ; which sight so revived the shepherd's spirits that he was greatly ravished with joy and daunted with fear ; joyful to see such a sum in his power, and fearful, if it should be known, that it might breed his further danger. Necessity wished him at least to retain the gold, though he should not keep the child : the simplicity of his conscience feared him from such deceitful bribery. Thus was the poor man perplexed with a doubtful dilemma, until at last the covetousness of the coin overcame him ; for what will not the greedy desire of gold cause a man to do ? So that he was resolved in himself to foster the child, and with the sum to relieve his want. Resting thus resolute in this point he left seeking of his sheep, and, as covertly and secretly as he could, went by a by-way to his house, lest any of his neighbours should perceive his carriage. As soon as he was got home, entering in at the door, the child began to cry, which his wife hearing, and seeing her husband with a young babe in his arms, began to be somewhat jealous, yet marvelling that her husband should be so wanton abroad sith he was so quiet at home ; but as women are naturally given to believe the worst, so his wife, thinking it was some bastard, began to crow against her goodman, and taking up a cudgel (for the most

[1] Save that, for convenience, it has been here and there modernised.

master went breechless) swore solemnly that she would make clubs trumps if he brought any bastard brat within her doors. The goodman, seeing his wife in her majesty with her mace in her hand, thought it was time to bow for fear of blows; and desired her to be quiet, for there was none such matter; but if she could hold her peace they were made for ever: and with that he told her the whole matter, how he had found the child in a little boat, without any succour, wrapped in that costly mantle, and having that rich chain about the neck. But at last, when he showed her the purse full of gold, she began to simper something sweetly, and, taking her husband about the neck, kissed him after her homely fashion, saying that she hoped God had seen their want and now meant to relieve their poverty, and, seeing they could get no children, had sent them this little babe to be their heir. 'Take heed, in any case,' quoth the shepherd, 'that you be secret, and blab it not when you meet with your gossips, for, if you do, we are like not only to lose the gold and jewels, but our other goods and lives.' 'Tush,' quoth his wife, 'profit is a good hatch before the door: fear not, I have other things to talk of than this; but I pray you let us lay up the money surely and the jewels, lest by any mishap it be spied.'"

The sequel brings play and novel into something like their old resemblance. Porrus and Mopsa (the old shepherd and his wife) prospered greatly; Fawnia, as they named their foster-daughter, grew in beauty as in years, "a jolly girl," and the cause latterly that Porrus' house was frequented by "divers rich farmers' sons"; till at last Dorastus (Florizel) and she meet and begin their adventures.

But to deal with the passage quoted, and with its substitute in the play. The great difference in treatment at this point between Greene and Shakespeare is due ultimately to the demands of the medium which the latter was employing. But the immediate explanation of Shakespeare's failure (shall we say?) to make as full use of the novel here as he did in earlier passages, is mainly the fact that he has saddled himself with Antigonus. Having been created to oppose Leontes and so earn his hatred, it was an almost natural consequence that he should be sent to bear the supposed "bastard" away, as Leontes decrees,

> "To some remote and desert place, quite out
> Of our dominions; and that there thou leave it,
> Without more mercy, to its own protection
> And favour of the climate."

Hence in the play we have the voyage, the landing in Bohemia, the sudden storm, the clamour of the chase, and the direction "Exit (Antigonus) pursued by a bear." The lonely deserted quiet of the novel, so beautifully appropriate, is sacrificed; and with it much else. The shepherd enters muttering his wrath against "these boiled brains of nineteen and two-and-twenty," who disturb his sheep with their hunting; and discovers the foundling. But there is no superstitious knocking on his breast; nor is there any soliloquy, to correspond with the narrative of Porrus' "doubtful dilemma," or anything of the secret "by-way" journey home, and the humorously realistic reception of the shepherd by his wife. Shakespeare is under the necessity of ensuring that no word of the child's fate shall reach the father yet. Instead, therefore, the shepherd halloos to his son—Shakespeare provides him with one—and the comedy of the scene is shifted from the old man and the foundling to the clownish rehearsal by this son of the sights he had just witnessed, namely, a whole ship's crew wrecked in the storm, and the bear that has already "half-dined on the gentleman" and "'s at it now"; (the destruction, that is, of all such evidence as might prevent the play's running to the normal five acts). That Greene's version by itself might be dramatised without appreciable loss, seems not impossible. There are two scenes—the sea-coast and the shepherd's house—and the pathway connecting them. But these might be combined, and nothing let slip, by opening before the house: for the humour of Porrus' dilemma lies entirely in the situation, depending really upon his being only half-conscious of the thoughts we can perceive passing through his brain; so that dumb-show, the gesture and behaviour of the actor while approaching the house, could do for us, much more effectively than any speech, what Greene is really doing with the aid of a freer, narrative medium, namely, interpret in a lively way what is implied in the situation. But of course, since it was necessary that Antigonus and the ship's comany must be destroyed—and destroyed, with a view to later developments, before some witness—the scene must be at the coast instead of at the shepherd's house; and so the readiest method of using the novel at this point becomes impossible. While, then, the dramatic medium called for some departure from the novel here as elsewhere, the much wider departure than usual and the particular form which that departure takes, are due to the other changes already made for similar reasons. And surely the result of leaving to Greene's credit one of his happiest inventions, unsullied and safe from the dangers of comparison, cannot possibly be called "vindictive." If Shakespeare remembered the quarrel of 1592 with bitterness, would he have worked so as to efface only the worst parts of his enemy's book?

I have said that the scene we have discussed might rouse a suspicion, in one acquainted only with the novel, of more than mere dramatisation. It is just

perceptible to a careful reader that the old shepherd is rather more subordinated in the play than in the novel to the main characters and plot. Perdita arrives in her new country with more ceremony. The presence of Antigonus and a ship, even the noise and hollooing of the chase—those " boiled-brains " of the huntsmen who explain the shepherd's entrance and his grumblings—these things keep Perdita as the real centre of interest, and take away from the prominence of the shepherd, placing him and the world he represents rather in the background of the picture. Beyond this, however, there is no hint given of what may follow ; and any suspicion awakened here will certainly have no confirmation till we cross over to the second part of the play.

But from the very first scene, almost from the first word of that second part, which we must now consider, we do begin to imagine another end in view. For while the novel still remains the basis of the play, the divergence throughout this part is so complete that no single scene can fairly be described as a mere dramatisation of the original narrative. And the explanation is that here at last Shakespeare is working, definitely and obviously, to eliminate the tragic and unpleasant portions of the novel, with a view to a *dénouement* of reconciliation all round. In Greene's story Bellaria drops dead in court on hearing of the death of her son Garinter. Shakespeare, keeping the matter secret till the end, puts Bellaria's successor, Hermione, into hiding only, that he may give her back to the repentant Leontes in a final tableau. The widowed Paulina must also be rewarded ; so Camillo at the very opening of this second part, unlike his prototype Franion in the novel, is discovered to be still, and very much, in the business of the story. These intentions necessarily affect the structure of the play ; and they explain the much freer use of Greene henceforward.

Note first Shakespeare's principal omissions. In the novel, Prince Dorastus, disguised as a shepherd, comes a-wooing of Fawnia, the supposed daughter of old Porrus. Before their elopement, and indeed to furnish something of a motive for elopement, Greene tells of the negotiations begun by the prince's father, Egistus, for the marriage of his son to a Danish princess. All this is not so much as referred to in the play. It was likely to be dropped by anyone dramatising Greene's story ; for it is after all only an episode in the plot. But an allusion might have been made to it with ease had Shakespeare so wished. That he did not so wish is probably due to the tone of the episode in Greene. For Greene uses this part of Dorastus' history to show him as the cynical despiser of love and sentiment, on the eve of his first vision of Fawnia. Shakespeare's lovers, his Florizel and Perdita, were conceived too ideally to need any such conventional contrast to impress us with the depth and beauty of their love. A " cynical " past for either is unbelievable ; it would jar upon our sense of the fitness of things. And with the suppression of this episode, Shakespeare avoided also presenting Perdita, like Fawnia, as once upon a time fickle in her love, but persuading herself to constancy as " hoping in time to be advanced from the daughter of a poor farmer to be the wife of a rich king."

Another omission worth noting must have been less easy. In the novel the lovers—together with Porrus, who is kidnapped and taken on board the ship—propose to escape to Italy ; but being storm-driven upon Pandosto's country, they conceal their names and intentions, giving out that they are Trapolonians on their way from Padua to Trapolonia. Pandosto, however, suspects that Dorastus has stolen Fawnia from her parents. He imprisons Dorastus ; and then becoming himself enamoured of Fawnia, attempts to win her love, not knowing of course that she is really his long-lost daughter. This ugly situation is relieved only when, after much delay, the whereabouts of the lovers is revealed by chance to Dorastus's father, and emissaries reach Pandosto from Egistus to explain these " Trapolonians." Here again the happy ending which Shakespeare designed forbade inclusion of an incident so unpleasant ; to have told or even suggested it would have poisoned the sweet air of *The Winter's Tale*. But how to omit it ? The only way was to shorten the period between the flight of the lovers and their pursuit. And indeed Shakespeare's choice of this method for this purpose is foreshadowed at the very beginning of his second part. We look for a short cut to the conclusion, instead of Greene's more leisurely approaches, when we note that Polixenes, unlike Egistus, knows how his son frequents the shepherd's cottage ; and in order to spy upon his conduct, proposes to go disguised there with Camillo.

But this speeding of the action to eliminate the unpleasant is best seen by comparing in some detail the methods employed by Greene and Shakespeare respectively to get the lovers clear of the country. In Greene it is the shepherd Porrus who first learns the truth about the love-making and is troubled. He decides to warn the king, and clear himself by revealing all he knew of Fawnia's identity. So one morning, having heard that " the king would go abroad to take the air, (he) called to his wife to bring him his holiday hose and his best jacket, that he might go, like an honest substantial man, to tell his tale. His wife, a good cleanly wench, brought him all things fit, and sponged him up very handsomely, giving him the chains and jewels in a little box, which Porrus, for

the more safety, put in his bosom. Having thus all his trinkets in a readiness, taking his staff in his hand he bade his wife kiss him for good luck, and so he went toward the palace." Now this very morning Dorastus had laid his plans to sail away with Fawnia; and he had taken one Capnio into his confidence to help him. Porrus meets Capnio, who suspects his intention from his tidy appearance, and so decoys him successfully on board the ship. Thus in the novel are Fawnia, her lover, and the necessary evidence of her high birth got conveniently together, to be storm-driven unawares (as already said) upon her father's kingdom. In Shakespeare, on the other hand, the king Polixenes, by learning of the love-making and surprising the culprits at the sheep-shearing, compels the prince to plan escape on the spur of the moment. There is no time to find or consult a confidant. Shakespeare therefore drops the Capnio of the novel, dividing his functions—first of aiding the flight, and second of trapping the old shepherd—between Camillo and Autolycus. The latter, Shakespeare's own and greatest addition to the characters of the play, created without the shadow of a hint from Greene, performs his part with the shepherd, delighting us at the same time with some of his best sallies. Camillo, meanwhile, the king's accomplice in the spying, having served his own desire to get home again to Sicily by forwarding, and even instigating, an escape thither, is on his way after the king to court; where he will duly relate the action of his young friends, and contrive to join the company sent after them. Shakespeare, that is, by having his own instruments ready for a more rapid accomplishment of this part of the story, secures also that the pursuit shall not wait till some one of the search-party, organised to find the missing prince, should chance to meet with "a fisherman that was mending his nets, when Dorastus and Fawnia (Florizel and Perdita) took shipping." The two consequently reach Leontes' court just before the arrival of messengers from Polixenes and of Polixenes himself; and Leontes, though attracted by the beauty of Perdita, as recalling his lost Hermione, is in no danger of displaying such grossness as Pandosto.

But Shakespeare did more than omit and suppress. His purpose of achieving a completely happy issue appears even more clearly in what he added to the story as told by Greene.

Autolycus the pedlar is the greatest, perhaps also the most significant of all the additions. As we have seen he was needed to supply in part the omission of the confidant Capnio. But this is only part, and a small part, of the function assigned to him by Shakespeare. Note that his entrance is earlier than is strictly necessary for this service alone. The story has advanced no further than the mere announcement of a shepherds' gathering, through the revelation of Polixenes' design to attend it in disguise, when, before the shepherds actually assemble, we first meet Autolycus on his way there also. He enters singing; and his songs are the life and soul of this little scene—a prelude to the revels and merry-making of the shepherd-feast that succeeds. The true function of Autolycus is to pitch the lyric note of the coming love-scenes, and generally to herald by his songs and his cheerfulness the dawn of happier days, of a cloudless summer for those we love and for all their friends.

Of Shakespeare's elaborations the most striking is the sheep-shearing revel. Built upon a casual phrase in Greene, this scene with the lovers' escape that grows from it, occupies no less than half of the whole second part of the play. Here again the change is made to create the right atmosphere for the new ending of all-round reconciliation. Moreover, the essence and effect of the divergence reveals plainly that Shakespeare's conception of Arcadia, of his shepherd-world, is very different from Greene's. The subordination of Porrus and his belongings at the close of the first part of the play pointed in this direction. And just as then Shakespeare's reshaping of the incidents did not efface Greene's version, but left it to exist by itself as a pleasant piece of narrative; so here it is significant that, while he reapportions everything else, he leaves altogether unused just the best part of Greene—the account already quoted of Porrus' setting out for the palace. To dismiss this detail by citing in explanation the obvious dramatic inconvenience of an extra scene and the absence of the shepherd's wife from among the personæ, is to miss some of the point; not only does Shakespeare omit the incident itself, but nothing even of its tone is carried over. Quite clearly this omission must be regarded as confirming the doubt raised by the treatment of the old shepherd in the earlier part of the play. Shakespeare and Greene conceive their pastoral worlds from entirely opposite points of view. Both men clothe their presentment of shepherd life with humour. But while Greene, centring the interest in Porrus and his household, works from a basis in realism, Shakespeare, thinking more of an effective foil to Perdita—"too noble for this place"—and also of the sphere best adapted for the exercise of the rogueries and accomplishments of the vagabond Autolycus, allows us glimpses of the pastoral world only in its more poetical aspects, its holiday revels and sheep-shearings. Whether or not, as Georg Brandes declares, Shakespeare was at all times "totally opposed to the realistic dramatisation of everyday scenes and characters," certainly in this

instance to follow Greene, for whom such scenes and characters had a peculiar attraction, would have withdrawn far too much of our attention from Perdita to surroundings created chiefly as a background to her lovely self. This more poetical, instead of a more realistic picture of Arcadia, then, is the ultimate reason why Shakespeare would not take so much as a hint from Porrus' preparation for his visit to the king, and why he subordinated Porrus and his shepherd-life in an earlier scene. Perdita and her love for Florizel were to be shown in an almost lyrical atmosphere; the tone appropriate to a more romantic conclusion than Greene's is suggested beforehand. It is a "winter's tale" that is in the making under our eyes. The stuff of the new fabric is quarried largely from the old; but here and there a fresh piece shows through; and the design of the architect has filled both new and old with the transfiguring beauty of imagination, with the glow of his own charitable human spirit.

Rigid Airship R34

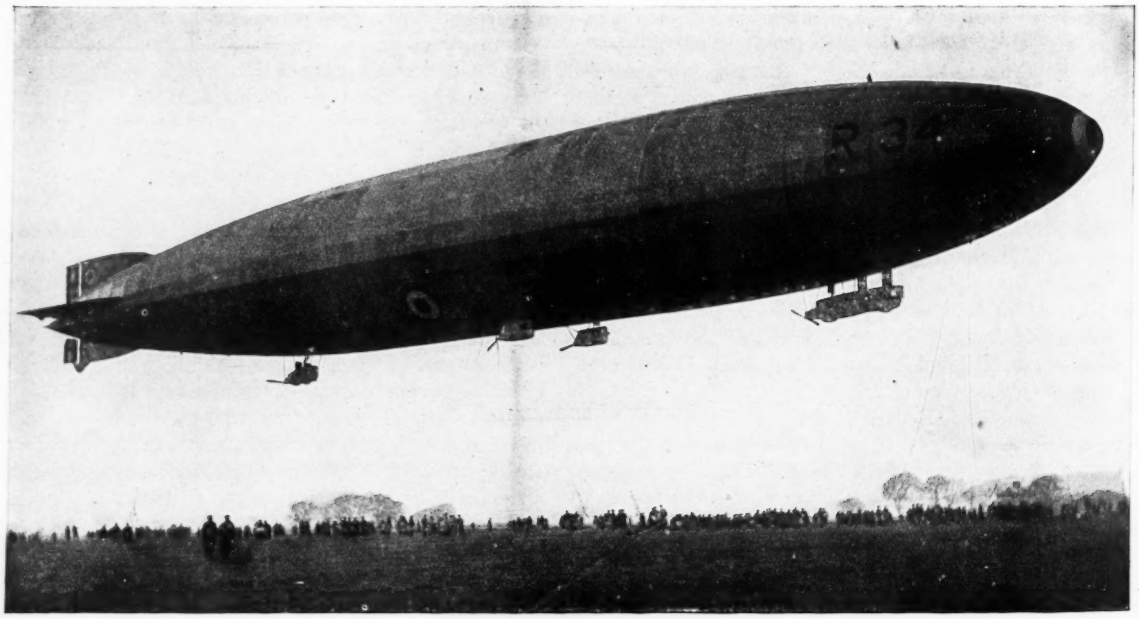
THE accompanying photograph depicts the rigid airship R34, the largest British airship which has actually flown up to the present date. R34 will be for ever noteworthy in the history of aerial transport as the first airship to undertake the crossing of the Atlantic Ocean.

The photograph shows clearly the streamline shape of hull, with its blunt nose, short parallel portion of hull, and long tapering stern. The overall length of the ship is 643 feet, with a diameter of 79 feet, and an extreme height of 92 feet.

The hull is divided by the main frames into nineteen compartments, containing the gas-bags which give a volume of approximately 2,000,000 cubic feet. The gross lift works out at approximately 59½ tons, of which the total fixed weight is 33 tons, giving a disposable lift of 26½ tons.

Five cars in all are suspended from the hull framework. Forward is the control-car, with the wireless cabin adjoining it. Immediately aft of this is the forward engine-car, containing one engine, the external appearance of which suggests that the whole is one large car. Amidships are the two wing-cars, each containing one engine, while at the after end is a larger car, housing two engines and an auxiliary control position. It will thus be seen that five engines are mounted in the cars. These are all of the same type and horse-power, namely 250 horse-power Sunbeams. The maximum speed is sixty-two miles per hour. Accommodation for the crew is provided in the internal corridor which extends throughout the length of the ship.

R34 was built by Messrs. William Beardmore & Co., Ltd., and is still in commission under the Air Ministry at the Airship Station, Howden, East Yorkshire.



Weeds

By George C. Gough, A.R.C.Sc., B.Sc.

WHAT is a weed? The first dictionary I take up says "The general name of any plant that is either useless or troublesome; a plant such as grows where it is not wanted and is either of no use to man or is injurious to crops." A simpler definition would be one on the lines of a definition of dirt—matter in the wrong place. A weed is a plant in the wrong place.

It is well known that a weed of one country may be the exotic of another. An instance of this occurred some years ago when a gardener in England sent seeds of a lovely greenhouse plant in his possession to a friend in the West Indies, thinking it would grow out of doors there. The friend planted the seed and anxiously waited for the plant to appear, but to his disgust found it was one of their common weeds.

Why are weeds unwanted? Not necessarily because they are useless, for I know one fruit-plantation where dandelions were so plentiful that their rootstocks were dug up, dried, and sold for adulterating chicory, or as a substitute for it. Nor because they are always small and insignificant, for some are large, shapely, and ornamental.

There are many reasons, some apparent and some only brought to notice by scientific research. As regards the former, it is obvious that a weed takes up space which should be occupied by the crop, and thus robs the crop. Every plant, if it is to come to perfection, requires light, air, moisture, and food, but weeds struggle with them for all these. A broad-leaved weed frequently gets ahead of a cultivated plant and shades it, with the result that, in the absence of sufficient light, the latter cannot develop the green colouring-matter, or chlorophyll, without which the ordinary plant is unable to grow. The chlorophyll bodies, minute as they are, are able to build up complex compounds, like sugar, from simpler materials only under the action of sunlight, and therefore shaded plants cannot normally thrive. They become yellow and sickly. Wheat, for instance, although a vigorous plant, cannot compete with weeds. At Rothamsted, the famous experimental station, a wheat crop was once left unharvested to sow itself without further cultivation. In three years the wheat had entirely disappeared in the wilderness of grass and weeds which had sprung up.

Plants require moisture, and in taking this up by the root-hairs,[1] they also take up their food, consisting of salts dissolved in the soil-water. Weeds compete with them for this, and rob them of their due. In such cases nearly everything depends on which gets the best start, and other things being equal, the plant which gets the start soon crowds out the other. It sometimes seems as if it is the weed that always scores in this respect.

Plants require air, not only because they breathe like animals by taking in oxygen, but also because the carbon, which is the basis of all organic substances, is obtained by them from the carbon dioxide in air and worked up, as stated above, into sugar and starch, and even more complex compounds. The air with carbon dioxide is taken into all parts of the plant through tiny mouths, or "stomata," which are largely automatic in their action. They are especially thickly placed on the under-surface of leaves where they are not so liable to be choked by dust as those on the upper surface of the leaf. As plants are commonly grown for commercial purposes as close together as is consistent with health, weeds, if allowed to grow naturally take up space and rob the crop of air.

Weeds may be even more definitely harmful, as when they are parasitic[2] on a crop. Perhaps the commonest instance of this is in the case of dodder, which, although it will prey on other plants, is frequently found on clover. The dodder is a small flowering plant which entwines itself around its victims and into which it sendssuckers by which it extracts nourishment for itself. It is practically colourless and has no chlorophyll, so that it must get its complex food materials from other plants instead of manufacturing them for itself. It has flowers, and produces seeds which are harvested with the clover seed. If the clover seed is not cleaned, and the dodder separated, the latter is sown with it and its life-history is repeated on the fresh clover plant. In this instance the dodder gets its water and salts from the ground as it is rooted, but in the case of the mistletoe, the parasite gets all its water and salts from the tree on which it grows. Here, however, it manufactures some of its complex compounds by means of its light green leaves, and it is termed semi-parasitic. Some climbing weeds are injurious because they drag down the plant; such are bryony and the bindweed, or convolvulus.

A less obvious danger from weeds, and because less obvious the more dangerous, is the fact that weeds become hosts for parasites of cultivated crops. The farmer, by means of rotation, changes the crops from field to field year by year, so that one crop does not succeed the same or a similar crop. Thus potatoes are followed by wheat or oats, and these by clover and so on. A pest, therefore, which lives on potatoes has little opportunity of living if no potatoes are planted for three or four years, and it gradually dies out. If, however, weeds which are related to the potato, such

[1] Tiny microscopic hairs very near the tip of the rootlets, fresh ones being constantly formed as the rootlet grows.

[2] A parasite is either an animal or plant which lives in or on another animal or plant.

as the black nightshade (*Solanum nigrum*) are allowed, or even if self-set potatoes are left to become " weeds," the pest may support and propagate itself on them, so that it remains in existence until potatoes are again cropped in the field. Cereal pests are carried over from one rotation to another by grasses which can usually support them, while weeds like charlock, wild mustard, etc., can act as hosts for turnip and cabbage pests.

Weeds may also be poisonous, and if such are allowed to appear in pastures, they may poison stock and the farmer may suffer much financial loss. Fortunately, this is a comparatively rare occurrence in England, but in Colorado the whorled milkweed has become a very dangerous pest owing to its poisonous property. In one county a 10-acre patch of this weed was responsible for the loss in 1917 of sheep worth 20,000 dollars, and in 1918 for 18,000 dollars worth. Another case is quoted where a flock of sheep was driven over a section of the country where this weed was growing, and the sheep, being very hungry, ate with disastrous results, for it is stated that the bodies of 400 sheep had to be removed before a motor could get through.

California suffers in a different way from a weed which has been introduced from the borders of the Sahara, probably in ballast. This is the Puncture Vine (*Tribulus terrestris*), which produces a number of prostrate stems, some eight feet long. At each joint a number of burs are produced, and each bur possesses two or more sharp spines about the size of carpet tacks. These are so disposed that, whichever way the bur falls, one spine will always point upwards. These will readily puncture a bicycle tyre, and even a motor tyre if it is somewhat worn.

One does not readily associate weeds with water, although duckweed will soon be recalled to mind, as well as deeper growing plants which spoil fishing, and even navigation. The American pondweed (*Elodea canadensis*) was introduced into England and became a menace to navigation in some of our waterways, but in Florida and Texas they have even a worse pest of rivers, namely the water hyacinth. It is a beautiful aquatic plant and is highly prized for use in aquaria in some parts of America, but its spread in St. John's River and the enormous sums spent in attempting its suppression have earned it the name of the " million-dollar weed." It seems to have obtained an entrance into the river from an ornamental pond, and now not only seriously impedes river traffic, but causes an annual loss of one-fourth of the value of the logs rafted down the river. It also interferes with fishermen setting their nets, piles itself up under low bridges until the pressure has overturned them, and it collects in masses and becomes a menace to health when it decays. A curious instance of loss caused indirectly by it has recently occurred. A couple of aviators were circling over the central portion of Florida, and spied what they thought was a beautiful green meadow. They came down on it, only to find that they had alighted on a vast expanse of water hyacinths, under which were several feet of water, and it was only at great expense that the two aeroplanes were salved.

In conclusion, a word as to some of the means of getting rid of weeds. There is no very easy way, especially when they are in fields. The farmer has to do what he can when there are no crops on the ground, but this occurs rarely, except during winter, when the weeds are dormant. He therefore tries periodically and systematically to rid his fields of these pests, and takes what he calls a cleaning crop. This is usually a crop such as potatoes, turnips, or mangolds, for during most of the summer when the weeds are growing he can either turn his men in to hoe up the weeds, or else use horse- or tractor-driven machines to do the same work without damaging the crop. When grain is grown, hoeing or cultivating can only go on for a short time after the plants have appeared above ground, but in the case of one of the commonest and most harmful weeds, namely charlock, the yellow-flowered weed so obvious on badly managed farms, spraying is resorted to. Here crop and weeds are sprayed with a solution of copper sulphate (blue vitriol), which scorches and blackens the charlock as it will most plants. The question at once arises, " Why does it not kill the wheat or oats ? " For the very simple reason that it runs off the upright glossy leaves of the grain, and lies on the hairy broad leaves of the weed. Sulphuric acid and ferrous sulphate (green vitriol) are also used, bracken being eradicated from grassland by the former.

Lawn sand recommended for the removal of weeds from lawns works on the same principle. It consists of sand and ammonium sulphate mixed together, and on being scattered over the lawn, lies on the broad-leaved weeds, scorching them. Ammonium sulphate, moreover, is a valuable nitrogenous manure, and when in solution, reaches the roots of the grass and stimulates growth so that grass is enabled to crowd out the exhausted weed.

Deep-seated and thick-rooted weeds, such as docks, dandelions, thistles, etc., must either be dug up where this is possible, or else continually cut down. Gradually, if the leaves which supply the food to the rootstock are not allowed to develop, the weed must die when it has used up its stored food-material. Such weeds are extremely tenacious of life, or they would have become extinct long ago.

Some weeds, especially sorrels, are characteristic of acid soils, and these will tend to disappear when land is neutralised by lime. Other weeds can be kept under by sowing down arable land to grass for a few years.

(*For Books of Reference, see p.* 50.)

Automatic Printing of Wireless Messages[1]

ONE of the recent developments in wireless telegraphy which is of more interest and importance to the general public than most, is the automatic printing of wireless messages in Roman type, a demonstration of which was given recently by Mr. A. A. Campbell Swinton to the Royal Society of Arts. It is interesting to recall that in January 1914 Mr. Swinton suggested that before long we might have a telegraph-printing-machine operated by wireless "in every house, telling the latest news to all the nation, as also to the newspapers, should any of these continue to survive the competition of this much more rapid method of disseminating intelligence." He thought, in other words, that it would soon be practical to operate "wirelessly" the telegraph-printing-machines which for years have been familiar occupants of London clubs and hotels. It is clear that if this could be done, there would be a great saving, not only in first cost and in expense of upkeep, but also because there would be no practical limit to the number of stations that could receive signals simultaneously from a single sending-station, so that it would cost no more to send to a thousand stations than to one. To some such an idea of the universal distribution of news might at the time have appeared fantastic, and may do so even now, but at any rate for an area comprising the British Isles and Western Europe it is now a possible thing.

It is well known that instruments connected to telegraph wires for printing messages are in daily use in newspaper offices and elsewhere. It is also well known that wireless messages can be recorded in various optical and mechanical ways, and even by an instrument analogous to a phonograph, but the ingenious method designed by Mr. F. G. Creed is the first to be adapted to printing *wireless* messages.

Suppose a message be telegraphed from London to a newspaper office in Sheffield. It is sent out of course in the ordinary Morse Code of dots and dashes; these dots and dashes may be recorded by an instrument (the receiver) at Sheffield which receives them by punching small holes in a moving strip of paper, this being simply one of several ways in which telegraphic messages are received. The strip of paper may next be passed through a second machine (the printer) which is really a typewriter controlled in an ingenious way entirely by the position of the holes in the perforated strip. In this machine the holes in the paper constituting the dots and dashes of, say, the letter F, operate a lever which causes the letter F of the typewriter to fall on a second strip of paper so that the letter is printed in Roman type. In this way all the letters and spacings in their Morse Code form are translated into letters and spacings in Roman type, and so it is that a message sent out in Morse Code from one town is received printed in words at another.

Fig. 1 will help to make this clear. The very small holes along the centre of the strip of paper are merely for the purpose of ensuring the regular motion of the strip through the instruments and have nothing to do with the signals which are denoted by the large holes.

It will be seen by comparison with the Morse signals (*b*) or (*c*) that a dot is denoted by two holes vertically over one another; a dash by two corresponding holes inclined to one another.

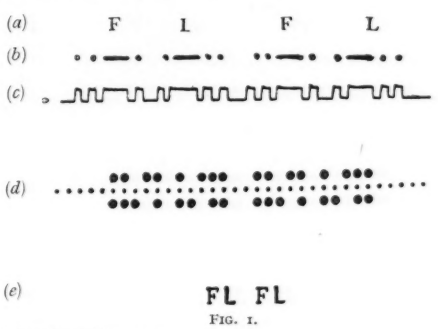


FIG. 1.

(*a*) Letters in ordinary type.
(*b*) Dots and dashes in Morse Code as represented in the usual way.
(*c*) The same "dots" and "dashes" recorded on a strip of paper.
(*d*) The same signals punched on a strip of paper by the Creed receiver.
(*e*) The letters printed by the Creed printer from the strip of paper above it.

Fig. 2 shows a photograph of the complete Creed receiving apparatus. To understand clearly the details of the working, the reader must see one in operation for himself. In brief, the working is as follows: The message to be sent is first translated into Morse Code by punching a perforated strip of paper in an apparatus with a typewriter keyboard. The message is now in the form (*d*) of Fig. 1. This paper-strip is next passed through the transmitting instrument, which sends out impulses of electric current in the dots and dashes of the Morse Code. These impulses actuate a special sending contact-maker which sends out the wireless waves.

At the receiving end the waves are picked up by a thermionic-valve receiver.[2] Their effect is amplified by an ingenious arrangement of valves. Impulses of current are thus supplied to part of the receiving

[1] References: *Journal of the Royal Society of Arts*, December 3, 1920, pp. 24–36 (G. Bell & Son, 1*s*.); *Nature*, December 9, 1920, pp. 472–4 (Macmillan, 1*s*.); *Wireless Telegraphy and Telephony*, p. 150, by H. M. Dowsett (Wireless Press, 10*s*. 6*d*.)

[2] Described in DISCOVERY, January 1921, p. 12.

apparatus known as the perforator. This is at present worked by compressed air, and is so designed that it punches on a moving strip of paper a duplicate of the arrangement of holes representing the dots and dashes which was used at the sending station for transmitting the message. When this is done the hard work is all over. It is then a comparatively simple matter to translate the Morse Code message into Roman letters with an instrument similar to the one used for several years in a newspaper office.

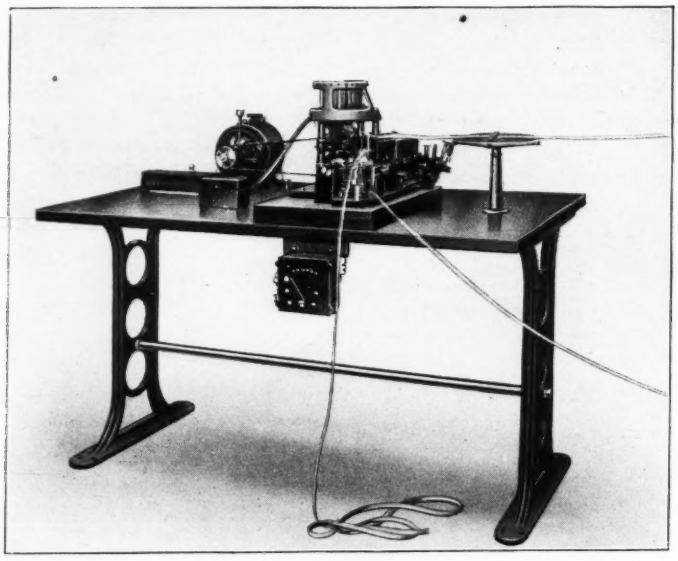


FIG. 2.

At the meeting at which Mr. Campbell Swinton demonstrated the Creed apparatus he picked up a message sent out by Horsea, near Plymouth, with the Creed receiver, printed it in Roman type, and projected the words and letters by means of a lantern on to the screen for his audience to see. Later in the evening a special message was sent him by wireless from the Eiffel Tower, and this too was automatically printed and then projected on to the screen. A facsimile reproduction of portion of this message as automatically printed is given in Fig. 3.

FROM THE EIFFEL TOWER PARIS

RECORDED ON A CREED TYPE-PRINTING

RECEIVER AT A MEETINM

OF THE ROYAL SOCIETY OF ARTS

FIG. 3.—FACSIMILE REPRODUCTION OF PORTION OF MESSAGE RECEIVED FROM PARIS, AS AUTOMATICALLY PRINTED.

The new thing about these instruments is that the receiver has now been adapted to wireless transmission so that messages from places as far distant as Paris may be automatically printed. Very successful experimental work has been carried out in this way between Cologne and Aldershot, and a wireless printing equipment of this kind is to be used between a large station in the Congo Free State and Brussels. The manufacturers are at present developing an improved form of printer in which compressed air is dispensed with. The present apparatus as adapted to wireless reception is capable of a speed of transmission of 180 words a minute, which is greater than that of the printer. The improved printer, however, will be capable easily of keeping up with the receiver. Quickness of transmission and reception is of course important, not only because more message can be received in a given time, but also because each message has a better chance of being received complete without interruption by " atmospherics " or other causes.

The following are suitable books on Weeds, for further reading :

Common Weeds of Farm and Garden. By H. C Long. (Smith Elder, 1910, 6*s.*)

Weeds of Farm Land. By Dr. W. E. Brenchley. (Longmans, 1920, 12*s.* 6*d.*)

Articles both on the subject generally and on specific weeds will be found in periodicals like the *Journal of the Ministry of Agriculture, Journal of the Royal Agricultural Society of England, Journal of the Highland Society*, etc.

Reviews of Books

English Wayfaring Life in the Middle Ages (XIVth Century). By J. J. JUSSERAND. Translated from the French by LUCY TOULMIN SMITH. (Fisher Unwin, 25s.)

It is a matter of difficulty to praise this book sufficiently, so real and delightful is the pleasure one has in reading it. It is a classic, and a classic that never bores. Its author is at present the Ambassador of France at Washington, and the author of notable works on Shakespeare, the literary history of the English people and on the English novel. The book under review appeared in French in 1884 and in English in 1889. That seems a long time ago, but age has not withered it. It appears in a second edition now revised and corrected; the notes have been brought up-to-date; new material has been included; and the whole book is beautifully produced.

It is a description of English life in the fourteenth century, a period of great interest when it became certain that England would be English and nothing else, when the language took definite shape, the principal institutions were founded, and the first masterpieces written. It was the time of the Black Death and of the Hundred Years' War.

The author has asked himself if this common life of our ancestors is possible to be discerned, possible to be reconstructed. Are the lives of kings and princes alone accessible to the historian through the remoteness of the ages? He is sure this is not so. To reach the heart of a nation, to get into touch with the four million instead of the four hundred, a patient and extended inquiry is

CHAUCER'S PARDONER.
(By kind permission of the Publisher.)

necessary. But this can be done. In doing so it is necessary to break more or less completely with the old habit of taking the ideas of everyday life in the Middle Ages from the descriptions, the eulogies and satires of the poets. For these embellish, imagine, colour, and transform. Valuable as it is, their work needs a check, and it is from the depositions of the records of England that the real information can be obtained. In the last

A BLIND BEGGAR CHEATED OF HIS DRINK BY HIS BOY.
(By kind permission of the Publisher.)

century thousands of documents have been printed and analysed—petitions, year-books full of reports of lawsuits, statutes, and ordinances. These are, so to speak, the catacombs from which an historian can unearth and sift the riches they contain.

The book is divided into three parts. The first deals with English roads and bridges, the security of the roads, the ordinary traveller and the casual passer-by; the next with lay wayfarers, the herbalists, charlatans, minstrels, jugglers, messengers, and pedlars, the wandering workmen, and the outlaws; the last with religious wayfarers, the pardoners, the wandering preachers and friars, the pilgrims, and the crusaders.

The whole is written by a man who is deeply in love with the times and the men he is describing. There are about seventy illustrations, some of them photographs, others reproductions of drawings in old manuscripts, which are distributed through the book not to give a reader an occasional rest but to illuminate the topic under discussion and to stimulate interest. Another excellent point about this book is that by means of unobtrusive footnotes the author gives chapter and verse for most of his statements. It is not only for this that references are valuable, but also for the fact that at any stage the interested reader is told exactly the book or series of books which he can rely upon as being best for further study. But footnotes and illustrations and excellence in printing cannot make a book; they can but embellish it. Its charm must be ascribed to other things, to the interest of the subject to every Englishman, and to the kindly, scholarly, and witty manner in which the whole tale is told.

One may open the book almost at any page to find pleasant and interesting reading.

"When a robber, murderer, or other evil-doer shall fly into any church upon his confession of felony, the coroner shall cause the adjuration to be made thus: Let the felon be brought to the church door, and there be assigned unto him a port, near or far off, and a time appointed for him to go out of the realm, so that in going towards that port he carry a cross in his hand, and that he go

not out of the king's highway, neither on the right hand nor on the left, but that he keep it always until he shall be gone out of the land." Dover was the port oftenest assigned to these funny fellows. The time allotted to clear out was often ridiculously, and no doubt purposely, short. " The distance from York to Dover over London Bridge was nearly 270 miles, and there are several entries of eight days being the allotted time, thus maintaining a rate of over thirty-three miles a day." This, barefooted, was excellent going; the felon must have indeed been sorry for himself.

The book is essentially one to buy, to read, and to keep. It is always delightful. Those who have not read it are to be congratulated on the happiness that awaits them.

P. K. F.

(*a*) *Secrets of Earth and Sea.* By Sir RAY LANKESTER, K.C.B., F.R.S. (Methuen, 8*s.* 6*d.*)

(*b*) *The World of Sound.* By Prof. Sir WILLIAM BRAGG, K.B.E., F.R.S. (G. Bell & Sons, 6*s.*)

These books have this in common, that each is written by a Fellow of the Royal Society, and that each may be heartily recommended to readers. They are just the kind of book that one is glad to have an opportunity of reviewing, for they are informed, clearly-written, understandable, and really give one an interest in the things the writers are dealing with. It is not often that the Royal Society writes so that those who never can become Fellows, or at best can become (in Mr. Wells's phrase) Fellows of the Royal Society, " in the sight of God," can follow its line of thought, or understand and remember the different things it writes about. But it happens sometimes, and here before us are two excellent cases in point.

(*a*) Sir Ray Lankester occupies in science a position not dissimilar to Mr. Gosse's in the world of letters. He has had a considerable and happy past; he keeps in touch with the present day, and he has obtained and retains the respect of his brethren.

He is always well-informed and he writes interestingly. This volume, like its predecessors, *Science from an Easy Chair* (Series I and Series II), and *Diversions of a Naturalist*, is mainly a revision and reprint of articles dealing with scientific matters published in daily or weekly journals.

He writes of the earliest picture in the world—a carving of certain representations of animals on a cylindrical piece of the antler of a red deer found in the South of France nearly fifty years ago,—of the art of prehistoric man, of portraits of mammoths made by men who saw them twenty-five to fifty thousand years ago.

A chapter is devoted to a graphic account of Vesuvius in eruption in 1871 and 1872, when the author made ascents with different friends. In another he deals with the blue colour of water and of other things such as the eyes, the sky, and glaciers. In writing on the biggest beast, the *Gigantosaurus*, he is loth to admit that antiquity has beaten the present age, for, as he explains, this biggest of quadrupeds lived probably in the sea, and is therefore to be compared with the whale and not the elephant of the present day.

There are also interesting chapters on Species, the Cross-breeding of Races, Suspended Animation, the Swastika, Coal, and the Story of Lime-juice and Scurvy.

(*b*) Sir William Bragg's book consists of six lectures delivered before a juvenile auditory at the Royal Institution at Christmas 1919. Its substance has already appeared in a series of articles in our contemporary *Conquest*. The author is known not only as an investigator of the first class but also as an exponent of physical science, whether the subject lectured on be highly technical or not, who has few equals at the present time. This book is certainly a model of popular exposition. A great number of experiments of a very interesting type are described, and they are well illustrated by drawings and diagrams.

The opening lecture deals with sound in a general way. Thereafter, sounds in music, sounds of the town, sounds of the country, sounds of the sea, and lastly, sounds in war are described; and whether Professor Bragg is explaining why there is a note given out when the wind blows past a wire, or in what way the hydrophone was used during the war to locate explosions at sea, he is always delightful and easily understood. No one is so clever that he cannot learn a very great deal from this book, or fail to take a greater interest in the sounds of everyday life. Those, too, who lament the decay of English prose, and fear that no scientist of to-day has carried the art of writing beyond the elementary stage, will find in this book a clear and persuasive style that will remind them of that of Tyndall or Faraday or some other idol of the past whom they admire.

A. S. R.

OTHER BOOKS RECEIVED

Personal Aspects of Jane Austen. By MARY A. AUSTEN-LEIGH. (John Murray, 9*s.*)

General Practice and X-rays. A Handbook for the General Practitioner and Student. By A. VANCE KNOX, M.B., and ROBERT KNOX, M.D., C.M. (A. & C. Black, 15*s.*)

The Antiquaries' Journal, vol. i, No. 1. January 1921. (Oxford University Press, 5*s.*)

Territory in Bird Life. By H. ELIOT HOWARD. (John Murray, 21*s.*)

A Textbook of Plant Biology. By W. NEILSON JONES, M.A., F.L.S., and M. C. RAYNER, D.Sc. (Methuen, 7*s.*)

British Plants: their Biology and Ecology. By J. F. BEVIS, B.A., B.Sc., and H. J. JEFFERY, A.R.C.Sc., F.L.S. (Methuen, 7*s.* 6*d.*)

A Handbook of Indian Art. Architecture—Sculpture—Painting. By E. B. HAVELL. (John Murray, 25*s.*)

My Electrical Workshop. By F. T. ADDYMAN. (Wireless Press, 7*s.*)